Broadcom MASTERS®
2015 Finalists

October 1-7, 2015
About Broadcom MASTERS

Broadcom MASTERS® (Math, Applied Science, Technology and Engineering for Rising Stars), a program of Society for Science & the Public, is the premier middle school science and engineering fair competition.

SSP affiliated science fairs around the country nominate the top 10% of 6th, 7th and 8th grade projects to enter this prestigious competition. After submitting the online application, 300 semifinalists are selected. From that select group, 30 finalists will present their research projects and compete in hands-on team STEM challenges to demonstrate their skills in critical thinking, collaboration, communication and creativity at the Broadcom MASTERS finals.

Broadcom Foundation and Society for Science & the Public thank the following for their support for 2015 Broadcom MASTERS:

- Samueli Foundation
- Science News for Students
- Deloitte
- Allergan
- Computer History Museum
- Marine Science Institute
- Sally Ride Science
- Wolfram Research
- Affiliated Regional and State Science & Engineering Fairs
- Parents, teachers and mentors of the 2,230 Broadcom MASTERS entrants
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2015 Broadcom MASTERS
October 2–6

Broadcom MASTERS (Math, Applied Science, Technology and Engineering for Rising Stars), a program of Society for Science & the Public, inspires and encourages scientists, engineers and innovators of the future.

The national science, technology, engineering and math competition for 6th, 7th and 8th graders, Broadcom MASTERS features top students nominated from SSP-affiliated fairs throughout the U.S.

The top 30 young scientists and engineers will be celebrated for their achievements in the Greater San Francisco Bay Area, where they compete for awards and prizes, including the Samueli Foundation Prize of $25,000, a gift of the Samueli Foundation.
2015 Broadcom MASTERS Finalists

Carolyn Marie Almonte
Burlington Township Middle School
Delaware Valley Science Fairs

Pranav Kumar Anandarao
Friedell Middle School
Rochester Regional Science Fair

Manasa Hari Bhimaraju
John F. Kennedy Middle School
Synopsys Silicon Valley Science and Technology Championship
California State Science Fair

Evelyn Ariana Bodoni
Challenge School
Denver Metropolitan Regional Science and Engineering Fair

John Blake Caven
Julia Landon College Preparatory
Northeast Florida Regional Science and Engineering Fair

Hannah Olivia Cevasco
St. Charles School
San Francisco Bay Area Science Fair

Soyoun Choi
Viera Charter School
Brevard Mainland Regional Science and Engineering Fair

Natasha Chugh
Rice Middle School
Beal Bank Dallas Regional Science and Engineering

Avery Parker Clowes
Oak Meadow School
Massachusetts Region IV Science Fair

Maximilian Junqi Du
Eagle Hill Middle School
Central New York Science and Engineering Fair

Andrew John Eggebraaten
John Adams Middle School
Rochester Regional Science Fair

Audrey Glende
Bonneville Elementary
Salt Lake Valley Science and Engineering Fair

Glenn Manuel Grimmett
The Weiss School
Palm Beach Regional Science and Engineering Fair

Joseph Arthur Huitt
Notre Dame Catholic School
California State Science Fair

Elizabeth Grace Kinsey
Charles P. Murray Middle School
North Carolina State Science Fair

Mikayla Ann Lindsay
Okoosha STEMM Academy
State Science and Engineering Fair of Florida - Ying Scholars

Bryant Michael Liu
Rocky Point Middle School
Long Island Science and Engineering Fair

Sebastian Lucas Mellen
Mt Everest Academy
Greater San Diego Science and Engineering Fair

Naya Kiren Menezes
Thurgood Marshall Middle School
Greater San Diego Science and Engineering Fair

Rohit Rahul Mital
Indus Center for Academic Excellence
Science and Engineering Fair of Metropolitan Detroit

Isaiah Logan O’Neal
Portola Highly Gifted Magnet
Los Angeles County Science and Engineering Fair

Nikolai Victorovitch Ortiz
Seashore Middle Academy
Coastal Bend Regional Science Fair

Annie Ostojic
Wilbur Wright Middle School
Calumet Regional Science Fair

Nicholas Antonio Perez
St. Edward School
Riverside, Inyo, Mono, San Bernardino (RIMS) Science and Engineering Fair

Anish Singhani
Diablo Vista Middle School
Contra Costa County Science and Engineering Fair

Sriyaa Suresh
Springhouse Middle School
Delaware Valley Science Fairs

Madison Alise Toonder
Florida Virtual School
St. Johns County Science Fair

David Yue
Rice Middle School
Beal Bank Dallas Regional Science and Engineering

Anusha Zaman
Glasgow Middle School
Louisiana Region VII-Science and Engineering Fair

2015 Broadcom MASTERS Finalists

Broadcom MASTERS 2015 Judging Panel

William Wallace, PhD
Judging Panel Chair
Georgetown Day School

Sarah Judd, BS
Curriculum Developer
Girls Who Code

Susan E. Mulroney, PhD
Physiologist
Georgetown University Medical Center

Patrick L. Murphy, BSEE/MBA
NASA Aerospace Technology Engineer
NASA Headquarters

Melanie Harrison Okoro, PhD
Environmental Scientist
National Oceanic and Atmospheric Administration

Todd Rider, PhD
Mad Scientist in Residence
Massachusetts Institute of Technology

Lynda Smith, MS
Lead Teacher, Science Teacher
Lakeshore High School Math & Science Center
**Awards**

The top finalist receives the Samueli Foundation Prize of $25,000, which recognizes the middle school student from this premier group of 30 finalists who demonstrates mastery of science, technology, engineering and math. He or she exemplifies how research, innovation and teamwork come together to achieve STEM goals that impact our everyday lives.

Other awards include:
- One finalist will be awarded the Marconi/Samueli Award for Innovation of $10,000. This finalist demonstrates both vision and promise as an innovator, and ideally, in the spirit of radio inventor Guglielmo Marconi, has applied concepts from electrical engineering.
- Eight finalists (two in each of the disciplines represented by STEM) will win a combined $30,000 in experiential or product awards for their ability and promise in each of the disciplines.
- Two finalists will receive Rising Star Awards to represent the United States as Broadcom MASTERS International delegates. They will travel with their local science fair’s delegation as student observers to the Intel International Science and Engineering Fair in Phoenix Arizona, in May 2016. These Rising Stars will be among a select group of Broadcom MASTERS International delegates from around the world.
- All finalists receive a $500 award from Broadcom Foundation to recognize their advancement to the Broadcom MASTERS finals.

**Awards Honoring Schools and Teachers**

In recognition of the important contributions of teachers to STEM education and the project-based learning of Broadcom MASTERS competitors, each of the 30 finalists’ schools will receive $1,000 from the Broadcom Foundation. Additionally, their teachers will be awarded with a classroom subscription to *Science News* magazine.

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**Why Middle School?**

Broadcom MASTERS® is the premier competition for 6th, 7th and 8th graders, where students demonstrate their mastery of math, applied science, technology and engineering through science fair competition.

Participants in Broadcom MASTERS are inspired, mentored and encouraged to stay with math and science through high school and beyond so that they are able to pursue exciting careers in science, technology, engineering and mathematics.

Students who participate in Broadcom MASTERS will be better prepared through project-based learning to meet the challenges of the future as tomorrow’s innovators. They will lead the way with scientific breakthroughs, engineering advancements and technological know-how.

These middle schoolers are invited to compete for prizes and awards in Broadcom MASTERS when they are top performers at their local SSP-affiliated science and engineering fair.

At the national finals for Broadcom MASTERS, the top winner is awarded the $25,000 Samueli Foundation Prize.

**The Process**

To participate in Broadcom MASTERS, 6th, 7th and 8th grade students must complete an independent science or engineering project, then compete in their local SSP-affiliated science fair. The top 10% of these students, a total of more than 6,000 in 2015, may be nominated by the fair for Broadcom MASTERS.

Nominees complete the Broadcom MASTERS application. Entries are judged during the summer, and in the fall, SSP and Broadcom announce the top 300 national semifinalists.

From among the semifinalists, 30 students are then selected as finalists for an all-expense-paid trip to showcase their projects, compete in teams and visit historical sites and organizations that celebrate innovation through science, technology, engineering and mathematics.
Carolyn Almonte, 12  
Burlington, New Jersey

The Effect of Phthalates Used in Consumer Products on Brine Shrimp Mortality and Motility

Project Background: Phthalates are plasticizer chemicals that are used in a wide range of consumer products, such as deodorant, nail polish, lubricating oil and vinyl flooring. Some research has shown a link between phthalates and reproductive and neurological damage in lab animals. Under current regulations, certain phthalates cannot be used in children's toys. Otherwise, phthalates still go into many products that people use every day. Carolyn experimented with brine shrimp to learn more about potential health effects of phthalates. She focused on two specific chemicals in the group: Dibutyl phthalate (DBP) and Dimethyl phthalate (DMP).

Tactics and Results: Carolyn experimented to find the 72-hour LC50 for each chemical. LC50 is the concentration of a chemical that would kill half of a group of organisms within a specific time. It gauges a substance's acute toxicity. Carolyn prepared separate solutions of DBP and DMP ranging from 2 to 1,024 parts per million. She added some of each solution to a petri dish with 10 brine shrimp. She also prepared three control groups in which the petri dishes had salt water only. Over the course of three days, Carolyn observed how many shrimp in each dish died. After finding the 72-hour LC50 for each chemical, Carolyn used those concentrations in a blind test with a control to see how DBP and DMP affected the brine shrimps' motility, or ability to move by using energy. The test was “blind” because Carolyn did not learn which solution went into each dish until afterward. That way, her observations would be more objective. “The experiment revealed that brine shrimp exposed to phthalates exhibit signs of neurotoxic effects, which affect their leg movements and respiration,” Carolyn says.

Other Interests: Carolyn plans to become an environmental engineer. She plays the French horn and swims with a team at her local YMCA. “In swimming, if you beat your own personal best time, but come in last, there is still a victory to be celebrated,” Carolyn says. “That means you should keep pushing forward through the whole race even if you can see that you are not winning. The goal is to improve and keep improving with each race and each swim.”

Pranav Anandarao, 14  
Rochester, Minnesota

Efficiency of Electromagnetic Regenerative Shock Absorbers Under Simulated Road Conditions

Project Background: Motor vehicles that are more energy efficient need less fuel and produce less pollution. To boost energy efficiency, some hybrid and electric cars use regenerative brakes. The systems capture some of the energy that would otherwise be wasted as heat when the car slows or stops. The systems convert that energy into electricity, which can then be used right away or to charge the car’s battery. Along the same lines, some auto manufacturers are investigating the idea of regenerative shock absorbers. The devices would convert some of the kinetic energy absorbed by the equipment into electricity that could help power the vehicle. Pranav wanted to see how different design variables might affect the voltage produced by such shock absorbers.

Tactics and Results: Pranav built regenerative shock absorbers with magnetic wire coils wound around a plastic pipe. Each design also had a dowel with magnets on it inside the pipe. Pranav varied different elements for his shock absorbers, such as the thickness of the wire, the number of winds around the pipe, and the number and configuration of the magnets on the dowel. Pranav also built a road condition simulator. That device had a small motor and a cantilever—a rigid board that’s anchored near one end, but not the other. Pranav then ran experiments with his shock absorbers. Each time, he manipulated only one design variable. Pranav found that the voltage produced by the shock absorbers increased as wire wrapped around the pipe got thinner, as the number of wire windings increased, and as the amplitude of vibrations from his simulator increased. He also found that configurations that let some repelling magnets float along the stack on the dowel produced more voltage than ones with all fixed magnets. “I learned from my project that electromagnetic regenerative shock absorbers are a very promising technology for the future,” Pranav says.

Other Interests: Pranav swims competitively with his local swim team. “I also enjoy playing chess, reading, and video games,” he says. In addition, Pranav likes to work with electronics and robotics using LEGO Mindstorms and Raspberry Pi. He hopes to become a nanosystems engineer.
**Manasa Hari Bhimaraju, 11**
Cupertino, California

*Low-Cost Animated Teaching Tool for Study of Elements in the Periodic Table with an Interface for the Visually Impaired*

**Project Background:** The Periodic Table of the Elements contains a wealth of knowledge about the elements and their atomic structure. However, learning how to use it can seem daunting. Hari decided to design the hardware and software for an integrated, interactive teaching and learning system for the Periodic Table. She wanted the system to be portable and low-cost. She did not want her system to require an Internet connection. Additionally, Hari wanted the system to have audio features. Those features would let visually impaired students learn from the system as well.

**Tactics and Results:** Hari used a Raspberry Pi and Arduino to design and build her system. With Hari’s system, a user can enter an element’s symbol with either a regular or a Braille keyboard. The system then provides details for that element. Pictures and animation show a model for an atom of the element, along with light-up LEDs (liquid electric diodes) and sound beeps to show the valences of its electrons. The system also uses a simulated Geiger counter to provide information about radioactivity. A voice generation feature also speaks all details out loud. To accomplish this, Hari did research, engineered the electronics for the device, and then input information for all the atoms. She also created a tool to let users learn more about radioactivity. Then she did lots of testing to make sure everything worked correctly. Among other things, she had to fix problems with the program’s voice, as well as issues where the system froze or had a lag in performance. Hari got feedback about her system from high school students. Two schools for the blind have reviewed the tool’s usefulness and are in the process of getting their students to use it. “The teaching system that I developed proved to be a very helpful tool for teachers as well as both sighted students and those with visual problems,” Hari concludes.

**Other Interests:** “I’m very active!” says Hari. Ball games are among her favorite activities, including basketball, tennis and wall ball. She even enjoys bouncing on her yoga ball. Hari is in the choir, plays violin and enjoys Indian dance and music. She hopes to become a biomedical engineer.

**Evelyn Bodoni, 13**
Centennial, Colorado

*Whatever It Takes*

**Project Background:** Some people might think that only struggling students cheat, but that’s not true. Evelyn became intrigued by the subject of academic misconduct after witnessing it among some of her classmates. “Why would gifted and talented students behave this way?” she wondered. “Because cheating is such a detrimental behavior, I was determined to investigate its prevalence in my school and some of the reasons that enticed students to cheat, so that corrective preventive measures could be implemented.”

**Tactics and Results:** Evelyn recruited middle school students in grades 5 through 8 for her study. The students participated voluntarily and without compensation, and all their identifying information was kept confidential. Evelyn randomly assigned 20 participants to a control group of students. She also assigned 16 students each to three experimental groups. Each group took a test in a room where an unseen observer could watch them. Students knew that the test answers were on the back, but they were told not to turn over the test form. Students in the reward test group were promised a reward for a score of 80 or above. A “decoy” student in the positive and negative control groups either encouraged cheating or discouraged it. Evelyn then analyzed the data on which students had cheated. “Results from this study have shown that there is a lot of academic dishonesty occurring in middle school,” Evelyn says. Overall, she reports, “Fifty-one percent of the students tested cheated.” Even though the control group had no incentive to cheat, 40 percent of them did so. The percentage of cheaters rose to 69 percent in the negative peer pressure test group and 81 percent in the reward test group. On the other hand, only 19 percent of the students in Evelyn’s study cheated when they were exposed to positive peer pressure that discouraged cheating.

**Other Interests:** Evelyn is passionate about fencing. “Each opponent challenges me in a new and different way,” Evelyn says. “The work ethic, decision-making abilities and creativity I have gained from fencing make me better in my everyday life,” Evelyn says. She has also coached wheelchair fencing for children. Evelyn plans to pursue a career in law.
Blake Caven, 12
Jacksonville, Florida

The Effect of Different Algorithms on Lacrosse Simulation Difficulty

Project Background: Algorithms are groups of rules for solving a problem in a series of steps. In a computer game, programmers use various algorithms in the game’s artificial intelligence, or AI. The game’s AI determines how particular characters or the game environment will respond to different actions by the players. Like many other computer game players, Blake had learned some patterns for the AI in a favorite game. Then an update changed that game’s AI, and the game got more difficult. “The experience challenged me to create and test my own algorithms to better understand how they work,” Blake said.

Tactics and Results: Blake built his own lacrosse simulation game with the programming platform Scratch from the Massachusetts Institute of Technology. He used basic math functions to calculate many features inside the game, such as the chances of making a shot or intercepting the ball. He also wrote algorithms for five types of computer-generated Defenders. One version always chased the ball. Another always moved back and forth in front of the goal. A third version moved at a random direction and speed near the goal. A fourth version used a mix of chasing the ball and patrolling the goal. And a fifth version tried to stay between the ball and goal at all times. Blake then experimented to see which Defender performed best against the others. His control version of the game had no goal defender at all. “I ran sixty trials by testing the control group and each of the five algorithms for ten trials,” explains Blake. “The most effective algorithm strategy, Intercept, tried to keep halfway between the ball and the goal and allowed an average of only 7.4 goals per trial, as compared to 50.2 for the control group,” Blake reports.

Other Interests: In addition to lacrosse, Blake is active in swimming, tennis, track and other activities. He hopes to become a computer scientist. “I am interested in using simulations and algorithms to create real-world solutions,” he says.

Hannah O. Cevasco, 14
San Carlos, California

Honey, I Found A Cure! Nature’s Healing Agent/Anti-Inflammatory

Project Background: Substances in some natural remedies may promote healing or other health benefits. Manuka honey is one natural remedy that piqued Hannah’s interest. Bees make the honey from the pollen of a certain tree native to New Zealand. Hannah had read that Manuka honey may have anti-inflammatory and healing properties. Indeed, some wound dressings and gels now contain a small amount of the honey. Hannah’s research examined whether the use of Manuka honey on a skin wound might help it heal faster than an untreated wound.

Tactics and Results: Working at a university lab, Hannah prepared cultures of human dermal fibroblasts. Those are cells found in skin tissue. After a skin wound, dermal fibroblasts move to the injury site. There they produce proteins to help form the structure for new tissue over the wound. Hannah flooded some of her cell cultures with diluted solutions of Manuka honey at 0.5, 1 and 2 percent concentrations. She also used a culture dish with a 1 percent honey solution that she replaced multiple times, in order to mimic the way someone would change a wound dressing. One of Hannah’s control dishes had cells with sterile water. Another control had cells and a sugar solution in the culture dish. Hannah made magnified images of each culture dish at various time points from the start of the experiment to 32 hours afterward. She then analyzed and reviewed the data. “The results of this experiment show that Manuka honey at a 1 percent concentration has a significant effect on cell migration, while the 0.5 percent and 2 percent concentrations have a minimal effect,” Hannah reports. “I think it would be beneficial to test more concentrations of Manuka honey between 1 percent and 2 percent to find the optimum dosage,” she adds.

Other Interests: “I hope to become a pediatric oncologist,” says Hannah. She describes herself as a dedicated athlete. She particularly enjoys volleyball and basketball and has played both sports competitively for the past five years. She plans to continue playing those sports in high school.
**Project Background:** Soy did not enjoy learning Korean at home when she was little. “As a stubborn kid, I would purposely say the alphabet wrong, angry at my parents for raising me as an oddball,” she recalls. As a young teen, Soy wondered about the effects bilingualism may have had on her and others at school. “Does the number of languages students are capable of affect their academic achievements and cognitive development throughout their stages of childhood and adolescence?” she asks.

**Tactics and Results:** After getting necessary approvals, Soy surveyed students at her former elementary school, her current school and a neighboring school. Questions asked about a student’s grade level, letter grades for each common core subject, how many languages each student could speak, and a rating of how well the student could speak any secondary language. Soy conducted the survey first after one nine-week grading period and again after grades came out for the following period. Next came “long days feverishly inserting numbers into my computer.” Then Soy analyzed her data. In general, bilingual students had lower scores than single-language students in reading and language arts. On average, however, bilinguals scored higher in math and science, and they had a slightly higher grade point average overall. “Bilingual students from third to eighth grade do have a higher GPA than the monolinguals in their grade, which shows that being capable of communicating in two languages does lead to increased cognitive development that helps bilinguals acquire high academic success,” Soy concludes. “Looking back at my childhood now, all I feel is gratitude for learning two languages,” she adds.

**Other Interests:** Soy doesn’t just play musical instruments. She sometimes takes them apart and puts them back together! “When I first cracked a piece of my violin, I was dismayed,” she recalls. To avoid getting in trouble, she fixed it up with parts from other musical instruments at home. Her work changed the timbre of the instrument, and an expert later told her the job wasn’t bad at all. “Ever since, I have become attached to upgrading different parts of violins and violas in search for a more beautiful sound,” Soy says. She hopes to become a robotics engineer.

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**Natasha Chugh, 14**
Plano, Texas

**Shower Water Usage Reminder System**

**Project Background:** “The challenge to conserve water is the driving idea behind this project,” Natasha says. For years, her parents had encouraged her to take shorter showers. Then Natasha did some research and learned her parents had a good point. “I realized that many people take water for granted,” Natasha says. “Thus, I wanted to help alter this human behavior by creating a system that reminded individuals of the dire urgency to change their terrible habits.” Her solution is an electronic system to monitor and remind people of their water usage during a shower.

**Tactics and Results:** “My engineering criteria/goal was that people will become more aware of their water usage and reduce their shower time in order to help conserve water,” Natasha explains. To do that, she built a system to measure water usage. During a shower, the system monitors water usage and plays audio messages as amounts pass different thresholds. A sensor connects to the shower’s water supply. It produces pulses at a rate that is proportional to the water flow. Input from the sensor goes to an Arduino set up with a laptop and speakers. The program for the system uses that information to calculate how much water a shower is using as it takes place. When someone’s water usage reaches different thresholds, the system plays prerecorded announcements. “If he/she crossed over a certain limit, the system is capable of annoying the person through constant obnoxious alerting,” Natasha notes, “thereby putting an end to their shower.” Natasha’s tests show that the system works. It accurately measures water usage during the course of a simulated shower. It also plays the correct announcements at different thresholds. Natasha believes that both individuals and society at large can benefit from the system. “My system helps save water and money,” she says.

**Other Interests:** “I love to draw and paint realistic yet unique aspects of our world,” Natasha says. “I believe that art is a relaxing and visual way to express one’s feelings.” She also has a 3rd degree black belt in Taekwondo. “The martial arts are an exercise routine and self-defense practice,” explains Natasha, whose other pastimes include volleyball and swimming. She plans to become a medical doctor.
Avery P. Clowes, 13
Bolton, Massachusetts

Position the Dropper

Project Background: During the nineteenth century, physicist William Thomsen invented a device known as Lord Kelvin’s Water Dropper. The device produces electrostatic sparks as two streams of water fall through metal coils into ungrounded containers. Each container is wired to the opposite coil. A slight imbalance in the charges of droplets on either side induces an electrical current. Positive charges build up on one side of the device and negative charges on the other. Opposite charges attract each other, so when charges reach levels that are high enough, an arc sparks between orbs on each side of the device. Then the device resets itself, and the process repeats. Avery wondered how placement of the coils in the device would affect the voltage.

Tactics and Results: “My project is an electrostatic generator that creates electrostatic charges from falling water,” says Avery. He tested three different configurations of Lord Kelvin’s Water Dropper. Each trial positioned the inductor coils three inches (approximately eight centimeters) lower than the last configuration. A control for the experiment had no inductor coils at all. “I hypothesized that the most charge would be produced when the inductors were at the droplet point of the stream,” Avery explains. “The droplet point is where the stream becomes a series of droplets rather than a cohesive stream. The droplet point is also the first point that each droplet has a chance of having its own slightly positive or negative charge.” That appeared to be the case in Avery’s experiments. However, he says, “There were not enough tests to statistically provide a viable answer.” A variety of technical problems explains why. The two water sources needed to be grounded with each other. Humidity or stray droplets might also have been causing shorts in the system. Determining the droplet point also proved to be difficult. Next time, Avery says he would do more testing with a larger version of the device. “Overall, it was a fun experiment, though frustrating at times,” he says.

Other Interests: Avery likes running and playing soccer, as well as band, math and other activities. He reads a wide range of books, from science and historical fiction to dystopian fiction, mythology, non-fiction and biographies. Avery plans to become a physicist.

Maximilian Du, 13
Manlius, New York

A New, Better, and Economic Method to Measure and Extract Caffeine from Drinks

Project Background: One cup of caffeinated coffee can keep some people awake at night. Yet some of those same people might have no trouble sleeping after a cup of tea with a lower level of caffeine. To learn more, Maximilian wanted to measure the caffeine in different types of drinks. However, a professor told him it would not be possible for him to use current methods to extract the caffeine. Maximilian’s additional research showed that those methods would either be too crude or too expensive for him to try on his own. UV spectroscopy is extremely accurate, for example, but it is also very expensive. Undeterred, Maximilian still wanted to proceed with his research. “I set out to create a new method to accurately extract and measure caffeine,” he says.

Tactics and Results: Maximilian wanted his method to be cheaper, better and safer than other existing solvent extraction methods for caffeine. Developing his method called for Maximilian to tackle three tasks. First, he needed a relatively safe and inexpensive solvent to carry caffeine out of the drink. Second, he needed a drying agent to remove water from the solvent after it had been separated from the drink. Finally, he needed a way to separate the solvent from the caffeine without breaking the caffeine down chemically. From there, he could determine the caffeine’s mass in milligrams for different types of drinks. Maximilian wound up using ethyl acetate as his solvent. A mixture of magnesium sulfate and calcium chloride served as his drying agent to remove water from the solvent. Distilling the solvent with a water bath left him with caffeine that he could weigh easily. He tested the method with three samples each of 10 beverages. He also tested a caffeine-free control of grape juice. Maximilian had trouble using the model for traditional decaffeinated coffee, which is made using chemicals that dissolve in ethyl acetate. However, his caffeine-extraction method worked well with all the other beverages in his study. “My method was on average only 7.8 percent different from UV spectroscopy,” Maximilian reports.

Other Interests: Maximilian enjoys swimming and various other sports. He plays both violin and the piano too. He hopes to become a chemist or chemical engineer.
Andy Eggebraaten, 14
Rochester, Minnesota

Building a Better Robotic Hand: Stronger, Wireless, Tactile Feedback, Controllable with an iPhone App

Project Background: Prosthetics can make life easier for people who have lost a limb. However, artificial body parts still need improvements. For example, sensory feedback could let someone with an artificial hand modify the pressure it uses to pick something up. Improved controls could also let someone move parts of the hand with more degrees of freedom. Andy decided to use his interest in robotics to start tackling these challenges. He had previously built a robotic hand that someone could control with voice recognition software on a laptop. He then set out to make the device wireless and more portable. He wanted to improve the hand’s strength so it could do more tasks, and he wanted it to be able to give a user some tactile feedback.

Tactics and Results: To improve his robotic hand, Andy needed to make changes to both its hardware and software. “First, I improved my robotic hand by strengthening the fingers and wrist, adding sensors to the fingers, and adding a Bluetooth shield to make it wireless,” he says. Then Andy focused on developing a custom iPhone app to control the device. His app incorporated a free voice recognition interface called OpenEars. Andy programmed that plug-in to recognize 58 phrases, and he mapped each one of those to a command for the robotic hand. Next, Andy tested the app and the hand to see how well they performed together. Among other things, Andy said each command phrase three times and recorded data on whether and how quickly the hand carried out each action. He tested the hand’s improved strength by seeing how much weight it could lift in a water bottle. He also tested the hand’s tactile feedback by comparing the effects of its normal “squeeze” command with a new command to “squeeze gently.” “Now the commands for the hand could be more sensitive for grabbing fragile objects,” Andy reports.

Other Interests: Andy taught LEGO Robotics to younger students this summer, and he hopes to become a computer software engineer. He plays clarinet in his school’s band and does cross country and track. “I also like high-adventure outings with the Boy Scouts, especially our backpacking trip,” says Andy.

Audrey Glende, 12
Salt Lake City, Utah

Ammonia: A Fishy Problem

Project Background: As an aquarium fish owner, Audrey noticed a problem. “Fish waste produces ammonia, a substance fatal to fish even in low concentrations,” she reports. Over time, nitrifying bacteria can deal with that problem. In an established aquarium tank, those bacteria convert ammonia from the waste into nitrites and then nitrates. Those chemicals are safer for fish, but it takes time for a fish tank to become established so that it has enough of the helpful bacteria. Until then, fish in the tank are at risk. “I wanted to know if there was a substance from an established fish tank that has enough bacteria already in it, that I can place in a new tank to speed up the nitrification process,” Audrey says.

Tactics and Results: Audrey prepared jars of diluted ammonia solution. She used one as a control and put materials from an established aquarium tank into the other jars. Those materials included a used filter sponge, gravel from the bottom of a tank, Java moss and mulm, which is decomposed organic matter. Every night for two weeks after treatment, Audrey measured ammonia levels with a color-changing ammonia test kit, logging the measurements and then analyzing the data. Out of all the materials, only the mulm reduced ammonia levels to zero over the course of the two weeks. “I came to the conclusion that of my four materials—gravel, Java moss, mulm and a filter sponge—mulm had the highest concentration of ammonia-fighting bacteria,” Audrey says. “If you want to establish an aquarium and you would like to speed up the nitrification process, place mulm from an established aquarium in your tank.”

Other Interests: Audrey has invested a lot of time learning to play music, and her efforts have paid off. “Now I can play the piano as easily as I can type on this computer, strum songs around the campfire on a guitar, and play songs from ‘Phantom of the Opera’ on the organ at full blast,” she reports. “I’m always up for a board or card game,” she adds. Her favorites include strategy games, such as chess, Clue and Stratego. Audrey hopes to become a nanosystems engineer.
Glenn Manuel Grimmett, 13  
Jupiter, Florida

Got Milk? Prevalence of Aflatoxin M1, β-Lactams, Sulfamethazine, and Tetracycline in South Florida Consumer Milk

Project Background: "I love milk and drink a lot of it," says Glenn. He wondered what chemicals might be in the milk sold in grocery stores in his area. One chemical of concern is Aflatoxin M1. That carcinogen is a common contaminant in grain that cows eat. Antibiotics are another concern. Farmers sometimes treat cows and other livestock with the medicines in order to treat or prevent disease or to help the animals grow larger. In general, farmers in the United States must discard milk if it contains any antibiotics. They must also discard milk if it has very high levels of Aflatoxin.

Tactics and Results: Glenn visited area grocery stores and bought 25 brands of milk with varying levels of fat in them. He refrigerated all the samples at the same temperature. He then tested each sample for different types of antibiotics and for Aflatoxin M1. "I found that 42 percent, or 10 of 24 milk samples, had Aflatoxin M1," Glenn reports. While the chemical was present, only one sample had high enough levels that would require action by farmers if they are using European regulations. "Even though Aflatoxin is a strong carcinogen, it isn't possible to achieve a zero contamination level in milk," Glenn notes. "My results agree with publications showing widespread contamination rates in many different countries." Glenn also found varying levels of two antibiotics. Sixty-eight percent, or 17 out of 25 of his samples contained either sulfamethazine or tetracycline. In the United States, farmers are supposed to discard milk if they detect antibiotics, Glenn notes. He believes his study found widespread low level antibiotic contamination because the test method he used is 30 to 40 times more sensitive than the methods approved by the FDA. "New technology is needed to improve antibiotic detection in milk," Glenn says. With so much milk to be tested, however, he also notes that test methods must be practical.

Other Interests: Glenn has been performing in plays since first grade. For sports, Glenn plays baseball and also holds a second degree black belt in Taekwondo. "I like that Taekwondo teaches courtesy, integrity, self-control, perseverance, and indomitable spirit, helping everything that I do," Glenn says. He plans to become a mechanical engineer.

Joseph A. Huitt, 14  
Chico, California

Honey! Where is all the Honey? The Effect of Stored Pollen on Honey Production

Project Background: Crop production in the United States relies heavily on bees to pollinate many plants. Honey produced by bees is also an important product and ingredient in many of our favorite foods. Unfortunately, colonies of honeybees have been in decline in the United States and elsewhere in the world. If colonies are not healthy, they can't provide services people need. Joseph's mother is a commercial beekeeper, and he often helps her at farmers markets. "I wanted to discover if pollen availability and the type of pollen would affect the strength of beehives and honey production," he says. "Improved colony strength would lead to increased economic returns due to higher honey production and improved pollinization of commercial crops."

Tactics and Results: Joseph believed that bees with access to pollen-rich areas would be healthier and produce more honey than colonies that did not have that ability to collect and store pollen. At the start of his two-year study, Joseph checked and treated 144 beehives for mites and signs of colony collapse disorder. In early spring of each year, he took six dozen of those hives to almond and prune orchards. For several weeks, bees in those colonies could collect pollen from the flowering trees. Meanwhile, the other six dozen hives went to foothill areas that did not have natural pollen sources during that period. Bees in those colonies got sugar water as their food source. In May of each year, Joseph collected all the hives and delivered them to six bee yards in Nevada. Each yard got a group of colonies that had been able to collect pollen, as well as a group that had gotten only sugar water. Joseph then observed the bees from May through October and collected honey from the hives at each yard. Bees that had been able to collect pollen from the tree orchards generally produced more honey than those who had gotten only sugar water. Those hives were generally stronger and healthier as well.

Other Interests: Joseph enjoys football, martial arts, and other sports, as well as fishing and swimming. "I can swim like a fish," notes Joseph. He also enjoys music, including choir, guitar and singing.
Elizabeth Kinsey, 14  
Wilmington, North Carolina

*Water Pollution and the Eastern Oyster: A study of Juvenile Crassostrea virginica*

**Project Background:** North Carolina’s oyster industry is an important part of the state’s economy. Ellie wondered how pollution is affecting oysters. “I live on the coast, and as coastal development has increased, so has sediment and pollutant loading in coastal waters,” reports Ellie. Her research project explored how common contaminants in surface runoff affect the growth of the juvenile oyster, Crassostrea virginica. Surface water runoff includes particulate organic content. It also contains excess fertilizer and pesticides.

**Tactics and Results:** One part of Ellie’s research tested how high levels of turbidity caused by suspended solids would affect oysters’ growth. Three groups of premeasured oysters went into a cage at a field site where the water had high turbidity and a high level of particulate organic material. Three other groups went into a cage at a different site with high turbidity but low organic particulates. Three more groups served as the control. They went into a hatchery tank with a constant food supply. Each week, Ellie measured the oysters’ length and calculated their growth. Oysters in the high turbidity water with a high organic content grew the most. In contrast, oysters in high turbidity water with a low organic content grew less. Ellie also tested the effects on oysters of a nitrogen-based fertilizer and a pesticide called carbaryl. She put some oysters on petri dishes into a control tank that had no treatment. Other groups of oysters went into tanks that had either high or low levels of fertilizer or a pesticide. Oysters exposed to high levels of fertilizer died. Ellie identified ammonium as the likely cause. The pesticide treatment showed little effect. However, Ellie then learned that carbaryl “is not toxic to oysters in low concentrations.” Ellie notes that she would want to do more testing with other pesticides. Overall, she says, “I conclude that runoff should be managed to promote oyster growth.”

**Other Interests:** “My favorite extracurricular activities are music and theatre,” says Ellie. She has recently played the lead in “Transylmania” and “The Wizard of Oz.” Other activities for the future veterinarian include Girl Scouts and Young Women Leading. Ellie also enjoys hiking, swimming and surfing, as well as reading.

Mikayla A. Lindsay, 13  
Niceville, Florida

*Force Field Fact or Fiction*

**Project Background:** Fictional characters use force fields in a variety of popular movies, such as Star Wars, Fantastic Four, The Incredibles, and The Hunger Games. Sometimes characters protect themselves, machines or even whole cities. In other cases, the force field becomes a tool to trap or imprison other characters. “I wanted to see if I could take a small step to making one,” says Mikayla. That curiosity led to her physics research question: “How do electric fields affect the size and shape of hemispherical droplets in different liquids?” The electric field would subject the droplet to a type of energy, and changes in the droplet’s size and shape would reflect the influence of that energy on matter contained in the electric field.

**Tactics and Results:** “The overall method of the experiment was to place a droplet between two electrodes and then study the droplet’s size and shape while applying an electric field,” explains Mikayla. Her experimental set-up included a high-voltage power supply, wires, copper electrodes, a wooden holder for the electrodes and an iPhone camera. For droplets, Mikayla used six different liquids. Those liquids were water, sugar water, salt water, vegetable oil, and two ionic liquids. To test each type of droplet, she placed a drop on the bottom electrode with a pipette. Then Mikayla applied current to the electrodes at a variety of voltages. Mikayla tested each type of droplet five times. She photographed the droplets at each voltage level during the experiment. “Every droplet got higher when electric fields were increased,” Mikayla reports. Sugar water droplets showed the greatest increases, compared to the other types of droplets. Surprisingly, though, some of the trials produced arcs between the electrodes “like a lightning bolt,” Mikayla says. When that happened, she shut down the power supply and tried the experiment again with smaller droplets.

**Other Interests:** “I like arts and crafts because in the end I have something useful that I made,” says Mikayla. “I particularly like origami because it uses geometry.” Her other interests include piano, karate and athletic courses with ropes. She hopes to become an astronaut one day.
**Project Background:** Bryant’s interest in biofuels was sparked by raking leaves in autumn. “I kept wondering whether I could use them to produce more valuable stuff,” he says. Biofuels are an alternative to fossil fuels, such as coal, oil and natural gas. Biofuel technology already makes it possible to produce ethanol fuel from corn and sugar cane. However, those processes use parts of the plant that can otherwise be used as food, and much of the plant still goes to waste. Making biofuels from parts of plants with higher levels of cellulose is generally more difficult and expensive. Something must break down the cellulose to produce sugars that can then be used to make ethanol. Nonetheless, a cost-effective technology could lead to less waste.

**Tactics and Results:** Bryant dried and ground bags of fallen leaves into a powder. Then he divided them into groups of test tubes. Some tubes were pretreated with different concentrations of either sulfuric acid or sodium hydroxide, which is an alkaline chemical. Different tubes in each group were also pretreated for an hour in a water bath at 50, 70 or 120° C. Additional tubes of ground leaves had no acid, alkaline or heating treatments. They served as Bryant’s controls. After any pretreatment, Bryant neutralized any added acid or alkaline chemicals. Then he washed each sample with distilled water and suspended it in a sodium acetate buffer. Bryant mixed in a commercial enzyme preparation to break down sugars in the material. He stored the tubes at 50°C for 72 hours. Lastly, Bryant measured the amount of glucose in each sample and analyzed the data. He concluded that pretreatment does help release simple sugars from fallen leaf waste. “Combination of pretreatments of high temperature heating and high concentration of acid or alkali does help in the release of the higher amount of simple sugars,” Bryant says.

**Other Interests:** “Drawing is a way I express myself and put my imagination on paper,” says Bryant. He also enjoys reading, playing the piano and playing tennis, and is active in a variety of school activities. Bryant hopes to become an astronomer. “I have a great interest in learning about space, planets and stars,” he says.  

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**Sebastian Lucas Mellen, 14**  
San Diego, California

**Project Background:** Sebastian set out to develop an Android app for smartphones that could do a range of algebra calculations. “Before I released MathSuite, you’d see my teachers struggling with grading self-written tests, and my classmates wrestling with algebra and physics homework,” Sebastian says. Although desktop computer programs were available, Sebastian said they were “overly expensive.” Plus, they required “a clunky computer.”

**Tactics and Results:** Sebastian’s app needed to be fast and accurate. He also wanted it to be visually pleasing and intuitive, so that people could use it easily. He programmed the app to perform core algebraic functions used in math, physics and other sciences. Sebastian also aimed to minimize the app’s demands on a smartphone. He wanted the app’s size when installed to be at or less than 7 megabytes. He also wanted random access memory usage to stay under 10 MB and central processing unit usage to remain under two percent in all cases. Search engine optimization, or SEO, was also a factor. SEO would have the app show up right away when someone searched for it in the Google Play store. To accomplish his goals, Sebastian used AppInventor, an object-oriented programming language from the Massachusetts Institute of Technology. He also worked with Eclipse and Notepad++ for editing and creating custom features. Adobe Illustrator helped him design an icon. After testing and debugging, Sebastian was ready to publish the app. Even after publishing the app, Sebastian has continued to work on it. For example, he added additional functions in response to user requests. “User data show that my user base is constantly growing and diversifying, which must mean that I’m doing something right,” Sebastian says.

**Other Interests:** Sebastian enjoys personal fitness training and sports, such as riding his road bike, running and basketball with friends. He also enjoys music and drama. “Theater has been a great place for me to be part of a team with other teenagers and find awesome friends,” he says. He plans to become an environmental engineer.
Naya Menezes, 14  
San Diego, California

**Effective Headgear in Soccer**

**Project Background:** "I enjoy playing soccer because it is a fun, high intensity sport that involves both smarts and athletic ability," says Naya. She has played the sport since she was three years old. Yet while Naya has gotten great satisfaction from competing with her team, she has also seen teammates suffer head injuries including concussions resulting from contact between the ball and head. Other injuries were caused by contact between players. Naya did research and learned that headgear could help reduce the risk of concussions. She decided to test different brands of protective headgear to see which worked best for reducing the force of an impact.

**Tactics and Results:** Naya's backyard became the stage for her experiments. The set-up used a hollow plastic mannequin with an accelerometer inside. That device detects and measures the rate of change in the speed of a moving object. Speed affects the force of a crash. Naya set the mannequin on a wooden pallet and had a pitching machine shoot balls at its head at different speeds. Data from those trials became Naya's control. Naya then conducted the same procedure multiple times with the mannequin wearing different types of protective headgear. Logger Lite computer software prepared graphs for each of the 1,680 hits in the experiments, and Naya downloaded the data into an Excel file. She then compared the data for the different types of headgear with each other and with the control. "The one headgear that I thought would be one of the worst came out to be one of the best in several trials," Naya says. She also compared the general effectiveness of wearing headgear at different speeds. She found that at 45 mph, the headgear reduced force more than at any other speed. "At higher speeds, all the headgear was less effective," Naya says. She concluded that headgear could prevent the most concussions among younger players. Those children would usually have impacts at lower speeds. Nonetheless, they are still very vulnerable to head injuries because of the stage of their physical development.

**Other Interests:** In addition to soccer and track, Naya’s non-academic activities include playing the piano and choir. She hopes to become a computer engineer.

Rohit R. Mital, 13  
Rochester Hills, Michigan

**Using Geometry to Protect the Environment and Save Lives**

**Project Background:** Air pollution was so bad when Rohit traveled to Asia that he had trouble breathing. "Pollution is a global problem," he notes. Then, while visiting an auto show, he noticed the pollution control equipment that treats exhaust coming out of the engine. "Since I love geometry, the channel design of these catalytic converters fascinated me," Rohit says. However, he noticed flaws with the shape of the design. "Particulate filters with square channels are used for reducing pollution," he explains. "However, they increase back pressure, thereby increasing vehicle fuel consumption." Rohit decided to see what other geometric shapes could be used. He also wondered which shape would best provide high performance at a reasonable cost. "I wanted to save lives by improving converter efficiency and making them accessible to all countries," says Rohit.

**Tactics and Results:** Catalytic converters typically have square channels that force vehicle exhaust to flow through their walls. As that happens, the equipment traps solid particulate matter while letting gases pass through. "The cell design of a good filter would have high surface area and low back pressure," says Rohit. He compared the common square shape for current catalytic converters to two other shapes—an equilateral triangle and a hexagon. For each shape, he also evaluated what would happen with different numbers of cells per square inch and different wall thicknesses within the equipment. He calculated the geometric properties for each cell design. A literature search added guidance to determine targets for strength of the equipment’s walls and other factors. Rohit found that only 19 out of 45 designs met certain minimum requirements. He then determined which of those designs performed best for each criterion. "There is no single cell shape and design that is best in everything," Rohit says. Yet while there were trade-offs, he concluded that one of the hexagonal designs performed best overall.

**Other Interests:** "I love piano, theatre and origami because they help me relax and allow me to escape to another world," Rohit says. He also plays the trumpet. For sports, Rohit enjoys football, swimming and tennis. He hopes to work in healthcare as a surgeon.
Isaiah O’Neal, 14
Los Angeles, California

Plant Electrophysiology Investigating Trigger Hairs: How Does Stimulation of Trigger Hairs Affect the Generation of Action Potentials in a B52 Venus Flytrap?

Project Background: “I’ve always been fascinated by carnivorous plants,” says Isaiah. “In fact, I have a whole collection of them outside my front door.” His 2014 science project found that the type of food given to B52 Venus flytraps affects the speed of their trap closure. This year he wanted to learn more about why that happens. Thus, Isaiah set out to study how the plants produce and respond to electrical signals called action potentials. Human neurons also use action potentials to send information through the cells. In particular, Isaiah wanted to see how stimulating one or more trigger hairs on the Venus flytraps would produce the signals. He also wanted to see how close in time those signals have to be in order to get the plants’ traps to close. The project helped Isaiah learn about electrophysiology and action potentials and how they relate to the human nervous system. In the process, he learned about computer programming languages and environments too.

Tactics and Results: Isaiah’s work used a dozen B52 Venus flytraps grown under identical conditions. Designing the testing apparatus took him three weeks of trial and error. “The most important traits you need to do well in science are curiosity, creativity and tenacity,” says Isaiah. Finally, he developed a system that would let him trigger trap hairs with uniform force, measure the resulting action potentials and test how close in time action potentials had to be in order to close the traps. Isaiah found that stimulating one trigger hair would produce one action potential, but a second hair stimulation would produce another action potential only if it came more than 0.229 seconds later. If a second action potential was produced in less than 18 seconds, the traps always closed. The likelihood that the trap would close decreased as the time interval between action potentials grew longer, up to 45 seconds.

Other Interests: Isaiah plans to become a biochemist. His various hobbies include chess, astronomy, reading and robotics. Even though his robotics projects generally don’t work the first time, Isaiah still enjoys them. “For me, this only adds to the excitement and the rewarding feeling I get when the robot does finally work,” he says.

Nikolai Ortiz, 12
Corpus Christi, Texas

What’s In Your Water? The Answer May Be Heavier than You Think!

Project Background: Texas waterways were the fourth most polluted in the nation, according to a 2013 report in Texas Monthly. At that time, Corpus Christi Harbor and Bay ranked among the top ten most polluted water bodies in the state. Beyond that, Nikolai learned that slight increases in ocean temperature could make heavy metal pollution in coastal waters more toxic to marine life. “I wanted to find the sources of this pollution,” Nikolai says. Heavy metals can build up in the tissues of marine organisms. From there, the toxic metals move up the food chain as bigger species eat smaller ones. “When humans eat this exposed marine life, the toxic heavy metals then get into their bodies,” Nikolai notes. Lead and mercury can damage the brain and nervous system. Cadmium has been linked to some forms of cancer and can cause problems for the lungs, kidneys and other organs.

Tactics and Results: Nikolai’s quest led him to sample water near places such as highways, industrial plants, golf courses, oil refineries, farms, plant nurseries and landfills. He took multiple water samples at each location. “I also ruined a lot of shoes!” Nikolai reports. After testing pH levels, he selected samples for each location that were within a normal range for surface water. He then processed and tested parts of those samples for lead, mercury and cadmium. Nikolai originally thought samples taken near a refinery would have the highest concentration but that wasn’t the case. Instead, the highest concentrations of those heavy metals were in the samples collected near a highway.

Other Interests: Nikolai loves hiking, biking, zip-lining, kayaking and other outdoor activities. He also greatly enjoys riding on roller coasters. He hopes to become a new type of environmental engineer: an “Environmental Imagineer.” “As an Environmental Imagineer I will create eco-friendly technology that can be used to run pollution-free, environmentally friendly theme parks and resorts that run on renewable energy,” Nikolai says. Profits could help fund additional research, he adds.
Annie Ostojic, 13
Munster, Indiana

A Novel Microwave Cavity Design Using Cylindrical Parabolic Reflectors to Optimize Energy Efficiency

Project Background: “I’ve always been a person to ‘think outside the box,’ but this time I had to literally think ‘inside the box,’” says Annie. The box was a microwave oven, and Annie’s goal was improving the energy efficiency for its cavity. For last year’s project, Annie designed a microwave container to cook food more thoroughly with less energy. In testing her design, however, Annie noticed a significant loss of energy around the corners of the microwave. “I knew I had to do something even more unconventional in my research by redesigning the cavity itself to refocus lost corner energy onto turntable food,” Annie says.

Tactics and Results: Engineering a better microwave cavity called for Annie to solve several problems: Where were the “hot spots” in an oven cavity where energy was wasted? What material would best reflect wasted energy onto the microwave’s turntable to cook food? And what shape would work best for those reflectors? Annie took measurements at different places to find the energy-wasting hot spots in small, medium and large microwave ovens. Then she did tests to compare the performance of seven kinds of reflector materials to each other and a poster board control. Aluminum foil reflector material helped the most for heating a glass of water in the oven. After making that finding, Annie experimented with three different designs for an aluminum foil reflector. She wanted to see which helped the oven do the best job of heating marshmallows. In those tests, Annie obtained the best results by placing cylindrical parabolic reflectors in each corner of the oven.

Other Interests: Annie loves zip-lining, parasailing and indoor sky-diving. “It is thrilling to meet the physical challenges that these activities provide,” she says. “In addition, I enjoy 25-mile biking excursions, swimming and running.” She also takes part in a variety of academic activities. Annie currently plans to become a mechanical engineer. “They say that I was born with goggles and a beaker in my hand,” Annie says.

Nicholas Perez, 13
Lake Elsinore, California

Saving the Lives of Wildland Firefighters with a Hydrated Polyacrylate Fire Shelter

Project Background: The 2013 Yarnell wildfire in Arizona killed 19 firefighters. Nick already had a provisional patent for a fire resistant material he developed for his science fair project in 2014. Nick designed a fire shelter that might help save firefighters’ lives out in the field, made of a fire resistant material he developed in 2014. His design uses a hydrated polymer to enhance its insulation properties.

Tactics and Results: Nick reasoned that the most effective forest shelter would protect against three different forms of heat transfer: radiation, conduction and convection. Thus, he built small-scale fire shelters with three different layers — a foil layer, a polymer/silica layer, and an air gap. He then did several tests to see how each design compared to a fire shelter used by the United States Forestry Service. Nick heated each kind of shelter with a propane torch or a convection oven and took measurements. The best shelter had a layer of sodium polyacrylate cells with water inside. Nick also experimented to see how each layer of insulating material contributed to its ability to withstand high temperatures. The combination of the approaches gave better results than the tests on individual layers would suggest. “When three types of insulation are used, the sum is greater than its parts,” Nick says. He believes the design could find uses in other products too, “from ice chests to home insulation.”

Other Interests: Nick loves building and designing model train layouts. His collection includes a variety of Disney trains. For sports, Nick enjoys cycling, running and basketball with his father, as well as nature hikes with his uncle. This summer Nick began a mentorship program at a pharmaceutical lab that does genetic research. He hopes to become a biomedical engineer and says science and engineering have taught him a lot. “The most valuable life lesson I have learned is that you need to use all of your senses in observation,” Nick notes. “Sometimes, what you see isn’t what is actually occurring in the world of science.” Smell, touch and hearing all play important roles too. “The most important sense is that of hearing, not just in experiments, but in everyday life,” he says.
Kanishka Ragula, 14  
Salt Lake City, Utah

A Hydraulic Solar Tracking System for Improving the Efficiency of Solar Panels

**Project Background:** Solar panels use photovoltaic cells to convert sunlight into electricity without emitting carbon dioxide or other air pollution. Solar trackers that change a panel’s position throughout daylight hours can boost its electricity output up to 25 percent. However, standard tracking equipment is complex and repairs can be difficult. Kanishka wanted to design a simpler, low-cost alternative to increase solar panels’ efficiency. The result is his hydraulic solar tracking system. “The device has no motors or gears,” Kanishka says, “just one piston and levers.”

**Tactics and Results:** Kanishka’s solar tracking device uses an aluminum cylinder filled with motor oil, connected to a hydraulic piston. Kanishka calculated the dimensions for the aluminum cylinder and piston so the device would be able to tilt a solar panel from an angle of 50 degrees in the morning to 122 degrees in the evening. Using Kanishka’s specifications, a local machine shop made the piston. The shop also helped him make sure the piston would have a tight fit and be leak-proof when it was connected to the cylinder. Kanishka painted the cylinder black and wrapped it in two layers of clear plastic. The layers trap heat from the sun and warm the motor oil inside the cylinder. As heat expands the liquid in the cylinder, the fluid pushes on the piston. Testing showed that the device in fact moved the solar panel in response to temperature changes, and those movements made the solar panel face the sun throughout the day. Cooling temperatures would then make the fluid contract and reset the device at night. “It felt good that my calculations and the actual performance of the system matched, and that I had a product idea,” says Kanishka.

**Other Interests:** “I like robotics because it is fun to build a robot from scratch, and programming it is challenging and fun,” Kanishka says. “When the robot is finally put together and it works, I feel like I accomplished something wonderful and I feel proud of myself.” And if a robot doesn’t work, Kanishka enjoys the challenge of debugging it. He plans to become a computer engineer.

Anish Singhani, 13  
San Ramon, California

Easy to Use Wireless Solution for Disabled People to Control Wheelchair and a Virtual Keyboard Using Brainwaves

**Project Background:** Anish felt moved to help after he met the paralyzed grandfather of one of his friends. Anish had already programmed several apps for Android and iPhone systems. Now he expanded his programming and computer skills in order to help disabled people. Anish engineered an electronic system that lets a person use brain waves to control various devices, such as a wheelchair and computer keyboard.

**Tactics and Results:** Anish started with a commercially available device for sensing electronic signals from a user’s brain. Then he designed both hardware and software to receive the signals and then interpret and process them. The hardware and software would then send commands to an external device. That device would then carry out the user’s commands to accomplish tasks the person could not readily do otherwise. For example, someone would be able to move more easily or communicate better. To make the system work, Anish had to deal with the limitations of the brainwave sensor. He also had to solve a variety of problems, such as finding a way for his computer to work with two Bluetooth devices—one that was built in, plus a second external one. The system Anish made worked with a model wheelchair. It also worked with a virtual keyboard that Anish designed and is making available for free on Google Play. “I exceeded my original design goals and ended up building a completely working product, which can actually control real-world devices using human brainwaves,” says Anish.

**Other Interests:** “It gives me intense pleasure and huge satisfaction when I build or create something,” says Anish. He’s known as a “techie guy” among his family and friends and would like to become a computer engineer. Working with engineering and technology is “my relaxation tool,” explains Anish. “I spend a lot of time researching technologies, which always inspires me to create new things.” Some of his projects include an electronic home automation system and a router-on-wheels to provide a local wireless network for first responders in case of an emergency or natural disaster. Anish demonstrates a variety of his innovations on his YouTube channel, called iShareTech. Besides engineering and his academic activities, Anish also enjoys soccer, badminton, chess and miniature paper crafts.
**Project Background:** Foul odors linger even after someone has stopped smoking a cigarette, and residue can remain on clothing, furniture, carpets, and other surfaces in buildings and vehicles. “For my science project, I wanted to see the effects of third-hand cigarette smoke on an organism,” says Sriyaa. She chose to work with fruit flies (Drosophila melanogaster) as her model organism. They have short life cycles and are fairly easy to maintain. “Fruit flies also have some of the same neurotransmitters in their brains as ours, so some of the effects that they experience due to the cigarette smoke are similar to what humans may experience as well,” Sriyaa notes.

**Tactics and Results:** Sriyaa tested how exposure to third-hand smoke affected fruit flies’ egg laying and climbing ability. She used nutrient agar plates, yeast, and a small inverted jar to design a chamber for fruit flies to mate and lay eggs in. She replaced the agar plates each day during the experiment. Flies in a control group had no treatment. Flies in experimental groups were exposed to a sponge imbued with cigarette smoke. Sriyaa observed how many eggs each group laid over five days. On the sixth day, she then measured how high the insects climbed inside a marked vial over the course of one minute. She repeated the experiment multiple times and then analyzed the results. Compared with the control group, the fruit flies exposed to third-hand smoke laid considerably fewer eggs. And while one day of third-hand smoke exposure didn’t significantly affect their climbing activities, multiple days of exposure did. “I discovered that Drosophila melanogaster exhibit adverse effects when exposed to third-hand cigarette smoke,” Sriyaa says. “This shows the possible effect on humans as well.”

**Other Interests:** “Violin is my passion and I love to express my feelings through the music that I play,” Sriyaa says. “Music helps me relax after a day of hard work.” She also enjoys animation and has taught herself how to use professional animation software. “I never feel satisfied unless I put the best work into anything I do,” adds Sriyaa. She plans to become a medical doctor.

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**Maddy A. Toonder, 14**  
St. Augustine, Florida

**The Effect of Sunblock Nanoparticles of Zinc Oxide and Micronized Sunscreen Chemicals on the Ability of the Bivalve Mollusk to Filter Bay Water**

**Project Background:** Oysters provide important services in coastal waterways. The animals provide shelter for other species and hunting grounds for wading birds. Oysters also help reduce erosion of the coast. Unfortunately, some oyster species are declining rapidly due to habitat loss, overfishing, disease and pollution. Some of that pollution includes very tiny particles of minerals and other chemicals from sunscreen. People wear sunscreen to protect themselves from harmful radiation from the sun. However, nanoparticles in mineral sunscreens and micronized sunscreen chemicals wash off when people swim or shower. Maddy decided to see how very tiny particles in some sunscreens affect the animals’ ability to filter bay water. If the animals can’t filter water well, they won’t be able to get enough food to survive.

**Tactics and Results:** The Matanzas River in Florida is an approved harvest area for oysters, so Maddy did her research with oysters harvested from there by a local fisherman. She separated the oysters into three tanks with local bay water. One tank was treated with a bit of zinc oxide sunblock whipped into some bay water. The second tank got an addition of chemical sunscreen mixed into bay water. Oysters in the third, untreated tank served as a control group. Each day during the experiment, Maddy replaced the water in all the tanks with fresh water from the same collection site. She measured the turbidity and other factors every 12 hours. Turbidity readings let Maddy gauge how well the oysters were filtering the tank water. “As the oysters filtered less, the water became cloudier and the turbidity readings increased,” she reports. “As predicted, the introduction of zinc oxide nanoparticles had caused a gradual and steady decline in the filtration abilities of the oysters.” Oysters exposed to micronized chemical sunscreen fared worse. They died after five days of exposure. “Therefore, chemical sunscreen seems to have an immediate effect on the oysters, while zinc oxide nanoparticles have a gradual effect on them,” Maddy says.

**Other Interests:** Maddy loves volleyball and practices between one and three hours every day. She is also passionate about music and enjoys learning and playing songs she hears on the radio. Maddy plans to become a veterinarian.
Project Background: Computerized tomography (CT) scans provide critical health information. They can help spot breast cancer and other diseases. However, the scans require many images. That process can expose patients to significant radiation, and too much radiation can increase risks for cancer. David was curious about an alternative technology called stereoscopic reconstruction. The technique uses a computer algorithm to make a three-dimensional (3-D) representation of something from two two-dimensional images taken from slightly different perspectives. Using the technique with two X-rays could expose someone to significantly less radiation than the person would get from a mammogram with many more images. “Stereo reconstruction is a leading field of study that plays a vital role in the detection of tumors, hemorrhages, and fractures,” David reports. Ideally, the method should be at least as accurate as CT scans are, he notes. Towards that end, David examined how the accuracy of a stereoscopic reconstruction varied with BlockSize. BlockSize relates to the number of pixels used by the algorithm to create the 3-D image.

Tactics and Results: David obtained X-rays of the same hand taken from slightly different perspectives. He measured the actual dimensions of bones and used that as a control. Then he experimented to see how varying the BlockSize would affect the accuracy of stereoscopic reconstructions. He found a parabolic trend, where accuracy increased up to a point as BlockSize decreased. After that point, further decreases in BlockSize correlated with decreases in accuracy. David thinks the X-rays might be “too unspecific” if BlockSize is too large. On the other hand, he thinks, there could be too much “noise” if the size is too small. With more work, David hopes stereoscopic reconstruction algorithms could one day replace CT scans. “The algorithm would accurately compute modeled lengths, as well as expose patients to little radiation and minimize the risk of inducing cancer,” he says.

Other Interests: “I enjoy robotics because it allows me to be extremely creative,” says David. He also loves computer programming and plans to become a computer scientist. In 2015, David’s team won an award for his school in the Verizon App Challenge.
The Inspiration for the Broadcom MASTERS

In recognition of the importance of STEM education and the importance of sparking insight and passion through project-based learning, the Broadcom Foundation is proud to sponsor the Broadcom MASTERS and congratulates all finalists for their hard work and dedication to following their passion in science, technology, engineering or math.

The inspiration to create the Broadcom MASTERS is found in the personal history of Broadcom’s co-founder, Dr. Henry Samueli. Just like the thousands of young people competing in science fair competitions throughout the United States and the world, Henry Samueli’s passion to pursue a career in engineering was ignited during the formative years of middle school with a ‘hands-on’ electronics project in his West Hollywood 7th grade electric shop class.

Henry Samueli convinced his teacher to let him tackle building a vacuum-tube short-wave radio he had read about in a Heathkit catalog, which he worked on every night for an entire semester. When he brought the assembled radio into school, the teacher plugged it in and it worked.

From that moment on, he was hooked. “That became my mission in life, from 7th grade onward, to find out how radios work.” He went on to earn his Bachelor’s, Master’s and Ph.D. degrees in electrical engineering at UCLA and his amazing career trajectory as an engineer/innovator led to the founding of Broadcom, which today is an international Fortune 500 company with over 11,000 employees.

Broadcom Foundation and Society for Science & the Public thank Dr. Henry Samueli and his wife Dr. Susan Samueli for their generosity in presenting the Samueli Foundation Prize, the top award of $25,000, at the Broadcom MASTERS.
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Broadcom Foundation is a non-profit charitable organization formed by Broadcom Corporation to advance science, technology, engineering and math (STEM) education by funding research, recognizing scholarship and increasing opportunity by advocating project-based learning and initiating programs like Broadcom MASTERS to inspire young people to pursue STEM careers.

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Through its acclaimed education competitions and its award-winning Science News Media Group, SSP is committed to inform, educate, and inspire.

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