Broadcom MASTERS®

2013 Finalists

Washington, DC
September 27–October 2, 2013

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About Broadcom MASTERS

Broadcom MASTERS®, a program of Society for Science & the Public, stands for Math, Applied Science, Technology, and Engineering for Rising Stars. The premier science and engineering competition for 6th, 7th, and 8th grade students, Broadcom MASTERS inspires middle schoolers to pursue their personal passion for science, engineering and math into high school. Learn more at www.societyforscience.org/masters and www.broadcomfoundation.org/masters.

The Broadcom MASTERS brings together young people who share a passion for innovation in STEM subjects (science, technology, engineering and math) and inspires them to stay with math and science throughout high school and into exciting careers.

Broadcom Foundation and Society for Science & the Public thank the following for their support of the 2013 Broadcom MASTERS:

- Samueli Foundation
- Elmer's® Products, Inc.
- *Science News for Kids*
- Deloitte.
- Allergan
- The Marconi Society
- Sally Ride Science
- National Academy of Engineering
- National Geographic Society
- Maryland Science Center
- The JASON Project
- Affiliated regional and state science & engineering fairs
- Parents, teachers, and mentors of this year's 1,695 Broadcom MASTERS entrants

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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.

From thousands of nominees nationwide, 300 semifinalists are named each year. Of these, 30 finalists are selected for the trip to Washington, DC, where they compete for awards and prizes, including the Samueli Foundation Prize of $25,000, a gift of the Samueli Foundation.

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SSP and the Broadcom Foundation wish to thank participating students and administrators from after school programs in the Washington, DC area who are joining us this year to learn about the Broadcom MASTERS and its transformative opportunities for young engineers and scientists.

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 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.

The national finals for Broadcom MASTERS are held in Washington, DC. The winner is awarded the $25,000 Samueli Foundation Prize.

The Process

To participate in Broadcom MASTERS, 6th, 7th and 8th grade students must first compete in their local SSP-affiliated science fair. The top 10% of these students, a total of more than 6,000 in 2013, may be nominated by the fair for Broadcom MASTERS.

Nominees complete the Broadcom MASTERS application. Entries are judged during the summer, and in August, 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 Washington, DC to showcase their projects, compete in teams and visit historical sites and organizations that celebrate innovation through science, technology, engineering and mathematics.

Awards

The top finalist receives the Samueli Foundation Prize of $25,000, which recognizes the finalist 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. Society for Science & the Public and the Broadcom Foundation welcome Allergan in their support of one of these awards in 2013.
- Two finalists will receive Rising Star Awards to represent the United States as Broadcom MASTERS International delegates. They will travel with their fair's official party as student observers to the Intel International Science and Engineering Fair in Los Angeles, California, in May 2013. 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. In addition, Elmer's generously supports Broadcom MASTERS at all levels of participation, as the 2013 Official Classroom Partner. Elmer's will provide a $250 Walmart gift card to each finalist as well as donate project boards and supplies for challenges during Broadcom MASTERS finals week in Washington, DC. Elmer's provides semifinalists $25 Walmart gift cards and $10 Walmart gift cards to nominated students who submit completed applications. Additionally, rebates are offered to middle school teachers and parents involved in SSP-affiliated science fair.

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 a $250 Walmart gift card provided by Elmer's. Elmer's will also provide a $500 Walmart gift card to the classroom of the top winner, and a $500 Walmart gift card to a STEM program in the winning student's community.

2013 Broadcom MASTERS Finalists

Eitan Acks, 14
San Diego, California

Tongue Untwister

Project Background: Eitan likes "to hypothesize how different materials or designs might benefit the world around us. Every time I look at something new, I ask myself what could possibly make it better," Eitan says. Inspired by his little brother, Eitan began hypothesizing ways to help him and others with dyspaxia (sometimes called apraxia). The disability affects the ability to communicate. Eitan wanted to improve on the simple exercises prescribed by speech therapists. One involves having patients lick a tongue depressor. So he set out to build a better device to strengthen the parts of the body used in speech, and to mend the connection between those muscles and the brain.

Tactics and Results: Eitan created five prototypes of his device, modifying and improving his design each time. The first two prototypes simply exercised the tongue through manipulating a tongue depressor. Starting with the third prototype, Eitan linked the tongue depressor to a joystick, in order to collect digital data. Those data could objectively chart a patient's progress, something often missing in speech therapy. He next created a few exercises and tested the device on his brother. Eitan hypothesized that using the device would allow patients with speech disorders to make greater and faster improvements. The first exercise involved pushing the lever up with the tongue for 30 seconds. Eitan's brother couldn't perform the test on his first day. But he showed steady improvements by the third and seventh days. "I have concluded that my device is capable of improving modern speech therapy for apraxia and other speech disorders alike," Eitan says.

Other Interests: Eitan loves to play soccer with friends, and to referee games. "I also have a passion for music. I began piano lessons a couple of years ago," Eitan says. Since then, he has begun playing the guitar, and is now teaching himself how to play the violin too.

Career of Interest: Nanotechnologist. "This technology focuses on a very small scale, yet it can make a huge impact in future projects. Today people can only dream of the possibilities, and I'd like to take part in the exciting adventure of making it a reality," Eitan says.

Aakshi Agarwal, 14
Hamden, Connecticut

TACE Inhibitors as Non-biological Drugs for Treating Rheumatoid Arthritis

Project Background: In 2012, Aakshi volunteered at a nursing home, where she soon made friends with the elderly residents. She realized many of her new friends suffered from rheumatoid arthritis (RA). The disease leads to inflammation of the joints. It also causes excruciating pain. The experience inspired Aakshi to learn more about RA—and design a new treatment for the disease. Aakshi's research taught her that a signaling molecule called TNF-alpha plays a role in the inflammation in RA. She also learned that current treatments for RA work by removing TNF-alpha. However, they are expensive, have serious side effects and are only partially effective. They also must be injected.

Tactics and Results: Aakshi wanted to design a new drug that blocked the body from making TNF-alpha. "I hypothesized that stopping production of TNF-alpha can be a more effective treatment instead of removing already produced TNF-alpha," she says. The new medicine also would be easier to take. She began by identifying the target for her drug—an enzyme called TACE. Aakshi next studied three-dimensional models of a protein bound, or connected, to the enzyme. Those models showed Aakshi how a new drug also could bind to TACE. She ended up designing 200 potential drugs. Aakshi also defined the essential features and estimated the potency of the medicines. "Once old enough to work in chemistry and biology laboratories, I would like to synthesize and test the TACE inhibitors I designed," Aakshi says. "The idea of treating RA stems from my love of helping others and these academic areas."

Other Interests: Aakshi is student council president, and active in debate and the technology student association. She also plays basketball and enjoys both classical Indian and modern dance. In her free time, Aakshi plays guitar, violin and piano. She also raises money for a nonprofit that provides clean water and sanitary facilities in poor countries.

Career of Interest: Neuroanatomist. "The discipline of studying the organization and function of the brain can help us understand our bodies even more," Aakshi says. She is also interested in helping people in another way, through political science. Next on tap: Volunteering in the office of an influential Member of Congress.

Sidhika Balachandar, 13
Gainesville, Florida

Can You Keep It Down?

Project Background: Sidhika has played flute since she was 6. Unfortunately, her practicing sometimes bothers her mother, who works out of a home office. Sparked by an interest in engineering, Sidhika began researching soundproofing options. She wanted to find something that worked well and looked nice. Sidhika knew looks were subjective, but that soundproofing could be objectively measured. So she designed an experiment that accurately measured the performance of different materials, including a decorative tapestry. "The project has aroused in me an idea for creating a company that specialized in finding, and possibly developing, art forms that could be used as sound insulators," Sidhika says.

Tactics and Results: Sidhika first researched different soundproofing materials. She also learned how soundproofing works. Sidhika hypothesized that materials with the right mass and absorption would suffice to soundproof her mother's office. She also hypothesized that a decorative material could perform as well as professional-grade insulation. (Plus, her mom would like it more.) For her experiment, Sidhika placed a speaker inside a cardboard box. The speaker played a tone while Sidhika measured its intensity at varying distances using a borrowed sound meter. She then took turns wrapping the box with different materials, including soundproofing roof tile, Styrofoam and tapestry. With her father's help, she plotted her data. The experiments supported her hypotheses. The professional-grade soundproofing roof tile worked best, closely followed by a double layer of tapestry. "The project has given me many ideas on how to soundproof my mom's home office," says Sidhika, who now plans more complex experiments.

Other Interests: Sidhika plays flute in her school and all-county bands. She also plays tennis outdoors year-round. She participated in Mathcounts, Science Bowl and Chi Alfa Mu, the National Junior Mathematics Club. Sidhika also learns a classical Indian dance form called *Bharatanatyam*. The dance has a rich history and combines "grace, purity and tenderness," Sidhika explains.

Career Interest: Engineer. "I want to be an engineer because I am good in science and math, and I am always curious about how things work or why something happens," Sidhika says. "Engineers contribute to society, and I want to positively impact the world." One specific area she considers focusing on is reducing pollution.

Drew Becker, 13
Heber City, Utah

Fingerprinting Oil Wells

Project Background: For Drew, the news highlighted the controversy over hydraulic fracturing, or fracking. In fracking, water, sand and chemicals are injected under pressure into oil and gas wells. Those wells can leak. The flames Drew watched dancing from a faucet showed how natural gas could seep into the water supply. What if fracking fluids could be tagged and tracked? That could help pinpoint any leaks. Drew designed an experiment to find out. "Hydraulic fracturing in order to utilize our national fuel reserves and the prevention of water pollution are equally important," Drew says. "I wanted to devise a win-win solution for environmentalists and drilling advocates."

Tactics and Results: Drew hypothesized he could track tinted microspheres or stained bacteria as they moved through groundwater. Similar methods could identify leaks due to fracking. Drew chose the Popo Agie River in Wyoming for his experiment. Along one stretch, this unusual river vanishes underground. Drew poured small amounts of his two fluorescent tagging agents into the river upstream. He then modified a 30-foot tool to collect samples from the broad pool downstream, where the river reappeared. He used advanced instruments to analyze those samples for traces of the two tagging agents. "Both candidates worked," Drew reports. He overcame lots of problems during the experiment, including growing, staining and counting the bacteria. Drew also came up with more questions, including how well his two agents would last in a fluid containing hydrocarbons. He hopes to answer this and other questions in follow-up experiments.

Other interests: Drew loves building and flying model rockets and aircraft. He also loves camping and is one rank shy of becoming an Eagle Scout. He swims, rafts, fishes and skis, as well as plays piano. Drew is currently learning to program in Python, and has read all the Harry Potter books.

Career Interest: Commercial diver. Drew picked this career after going diving on vacation in Florida. One idea would be to take people on diving tours. Drew also considers combining diving and welding, and becoming an underwater welder. "That would be an interesting but difficult career!" he says.

Michael Becker, 14
Flower Mound, Texas

Different Temperatures, Different Pitch

Project Background: Michael plays trombone in his school marching band. The band plays outside during football games. They begin early in the school year. As the season goes on, Michael and his band mates play in a wide range of temperatures. The changes in weather produce a curious effect. "I noticed in the cold temperatures that the band sounded off pitch," Michael says. Intrigued, Michael last year created an experiment that measured the effect of temperature on pitch. He used the trombone, a brass instrument. This year, Michael expanded that experiment to include woodwind, string and electronic instruments. "Each of the instruments reacted very differently, which was very surprising," he says.

Tactics and Results: Michael selected a trombone, clarinet, guitar and electronic keyboard for his new experiment. He monitored the weather so he could conduct his experiment at intervals of 5.5 degrees Celsius. Michael left each instrument outside to adjust to the air temperature. He then played five F notes, measuring the pitch of each note using a tuner. He next averaged the five notes. That showed Michael how far off the average was from a perfect F. Surprisingly, the pitch of the trombone grew flat as the temperature fell, but the pitch of the guitar grew sharp. (Unsurprisingly, there was no change with the electronic keyboard.) "The results of this project proved that the air temperature does impact the pitch of musical instruments," Michael says. For future experiments, Michael says he could use the algebraic formulas he developed to predict how sharp or flat an instrument would sound, based on the air temperature.

Other Interests: Michael enjoys being outdoors and bonding with friends while camping. A Life Scout, Michael enjoys the challenge and reward of working toward becoming an Eagle Scout. "My Dad and Grandpa are both Eagle Scouts and I cannot wait to join them," he says.

Career Interest: Accountant. Michael has two reasons for wanting to become an accountant. The first is his father is an accountant. "The second main reason is that I absolutely love math," he says. Since Michael would regularly work with numbers, the career could be the right one for him.

Rebecca Bloomfield, 14
Colorado Springs, Colorado

A Slippery Slope: The Effects of Slope and Remediation Treatments on Post-Fire Sedimentation

Project Background: Rebecca and her family were evacuated during the Waldo Canyon fire in 2012. The fire eventually destroyed nearly 350 homes in Colorado Springs, Colo. Luckily, Rebecca's home survived. However, debris flows and flash floods continued to threaten her community. On visits to the burn area, Rebecca saw straw had been used to cover the bare soil. She knew the blackened soil could repel water. She also knew straw floated. That got Rebecca wondering if other treatments might be more effective in keeping exposed soil from washing away. That motivated her to create an experiment that tested different cover materials, using a variety of slopes. "I was inspired to help," Rebecca says.

Tactics and Results: Rebecca simulated 0% to 70% grade slopes with a wooden trough supported by adjustable stands. She laid down three kilograms of gravel in the trough. On top she placed her test material: mulch, garden mat, straw, logs or orange peel. Rebecca next simulated an intense rainfall, repeating the experiment three times with each treatment over 14 different slopes. (She used bare gravel as a control.) Each time, Rebecca collected and weighed the gravel that washed off her slopes. "The most difficult element of my project was designing a testing method that was both replicable and representative of natural conditions," she says. Rebecca hypothesized that mulch would be the most effective in reducing sediment loss at all slopes. Statistical analyses left Rebecca's hypothesis unsupported. "The most effective treatment was dependent on slope," she says. However, her findings could be useful in prescribing the best treatment for any particular slope.

Other Interests: "I enjoy playing the flute, science fair, math clubs, running and rock climbing," Rebecca says. "The flute is fun and challenging. Math clubs and science fair go beyond what's taught in class. And running and rock climbing are just as mental as they are physical," she says.

Career Interest: Biophysicist. Rebecca grew up in the woods, sparking an interest in flora and fauna. "I enjoy figuring out how things work, so a job examining what makes plants and animals work is fascinating to me. Biophysics combines my interest in mathematics and physics with my love of biology," she says.

Emma Ashley Burnett, 12
Pittsburgh, Pennsylvania

Elements of Fluorescence

Project Background: Last summer, Emma took a special tour of a feldspar mine in North Carolina. The nighttime tour used ultraviolet light, also called UV or black light, to reveal the glow of fluorescent minerals inside the mine. "When the guides turned the UV lights on, I was amazed. Everything fluoresced such beautiful colors," Emma recalls. The deposits of feldspar mostly glowed pink to red. In another place, the mine walls fluoresced blue. "They did not know why it fluoresced differently, and I wanted to find out," Emma says. "That is how I came to this project." Emma received four known, and one unknown, feldspar samples from the mine. She then tackled the mystery.

Tactics and Results: Emma first researched fluorescence. She learned how different impurities, called activator elements, cause the same mineral to fluoresce in many different colors. She then photographed her five samples under both natural and UV light. "My hypothesis was that an element not found in the known feldspar samples made the unknown sample fluoresce blue," Emma says. Emma's mother is in a Ph.D. program in chemistry at a local university. There, Emma got the permission (and training) to use a powerful microscope. She used an instrument, called a spectroscope, to examine crushed samples of each mineral. The spectroscope revealed the elements that made up the minerals. Emma identified the main elements found in all feldspar. She next did the same for the differing activator elements in her samples. In most of the samples, iron and manganese appeared. In her unknown sample, Emma found molybdenum and tungsten. "My results supported my hypothesis," she says.

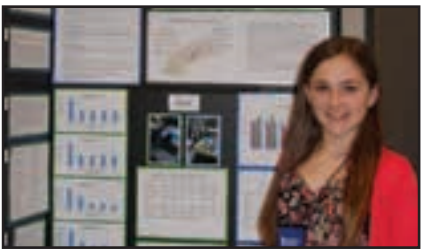
Other Interests: Emma has many hobbies, including karate, reading, writing for her school poetry magazine, knitting, mining and learning about science. Karate gives her a sense of confidence, and it is also a good workout. Meanwhile reading just lets her imagination flow, while writing and knitting allow her to create something.

Career Interest: Plasma Physicist. "Plasma physics interests me as a career because it involves science and engineering. I love to take a problem and design a new and better solution. The problem of energy storage is one of great importance. New discoveries in this field could potentially help the entire world," Emma says.

Elizabeth Corn, 14
Tampa, Florida

The Effects of Nanoparticle Size on the Antibacterial Effects of Zinc Oxide (ZnO) on E. coli Bacteria

Project Background: Elizabeth grew interested in nanotechnology after reading an article about the medical benefits of the tiny particles, measured by the billionths of a meter. She knew nanoparticles could kill cells. That made them useful as part of future treatments for diseases, including the cancers that affected her mother and other loved ones. "I was fascinated by how something so small could have such a strong effect," Elizabeth says. She hypothesized that smaller nanoparticles would work better than larger particles in treating disease. But her investigations suggested more research was needed on the size effects of nanoparticles. So Elizabeth designed her own experiments to learn more.



Tactics and Results: Elizabeth worked with zinc oxide nanoparticles, a common sunscreen ingredient. She used three size ranges: 18, 35-45 and 80-200 billionths of a meter. Elizabeth tested the various nanoparticles on different dilutions of a strain of *E. coli* that doesn't cause infections. She mixed the nanoparticles with the bacteria and allowed them to grow, both in petri dishes and in a liquid. Elizabeth waited 17 hours before counting the bacterial colonies that had grown. She also measured the turbidity, or cloudiness, of the liquid. These measurements showed how effective each size of nanoparticle was in killing bacteria. The smallest nanoparticles had the biggest effect, she says. While the experiment confirmed her hypothesis, it took a lot of work to get there. Elizabeth says she had to teach herself years of biology and chemistry. "Doing this science fair project was an incredible experience and I learned more than I ever imagined possible," she says.

Other Interests: Elizabeth is a competitive figure skater. She approaches skating with a scientific mind. That means breaking down the mechanics of landing, say, a double toe-loop jump without falling. "Defining the problem of what is causing me to fall helps me to fix this problem and hopefully land the jump," she says.

Career Interest: Neuroscientist. "Becoming a neuroscientist would not only meet my aspiration of becoming a medical researcher, but at the same time I would be researching one of the most fascinating and mysterious organs in the human body—the brain," Elizabeth says.

Keoni Gandall, 14
Huntington Beach, California

Engineering Pink Salt!

Project Background: In seventh grade, Keoni learned about DNA. That cemented his interest in genetics. After class, Keoni's science teacher suggested ordering a special kit. The kit would allow Keoni to genetically engineer *E. coli* bacteria using the genes from a bioluminescent jellyfish. "I got it and just [kept] on experimenting ever since," Keoni says. The kit included a small DNA molecule called a recombinant DNA plasmid. The plasmid acts as a vector—it allows genetic material from the jellyfish to be introduced into the *E. coli*. Keoni next decided to work with halobacteria, a microorganism that tints salt pink. He wanted to make the microorganism glow green. But there were no vectors. "So I made my own," Keoni says.

Tactics and Results: Keoni worked with halobacterium NRC-1, a microorganism called an archaeon. To genetically alter the halobacteria, Keoni started by creating a vector. He ordered synthetic DNA online. Next, Keoni amplified the DNA. That means he created multiple, exact copies of it. He started off using an inexpensive machine he bought on eBay. It didn't work. So Keoni did it by hand—repeating the necessary heating and cooling cycles 30 times. "A pain," he says. He then joined together the DNA fragments. Next he analyzed the DNA. His handwork succeeded. Unfortunately, Keoni could not successfully introduce the DNA into the halobacteria cells. Still, he proved it possible. "I engineered a plasmid! Using different genes for replication and antibiotic resistance I engineered it to do exactly what I wanted (hypothetically, because I did not have the money to go through ALL the testing required)," he says. "I simply wanted to know more and directed myself there."

Other Interests: "Pretty much science is my life," Keoni says. He is very interested in do-it-yourself biology, and likes to test genetic systems in bacteria at home. "I just simply have a passion for that and it is what I do," he says.

Career Interest: Medical scientist. Keoni is interested in this field because of its ties to synthetic biology—"It's what I love," he explains.

Mihir Garimella, 14
Pittsburgh, Pennsylvania

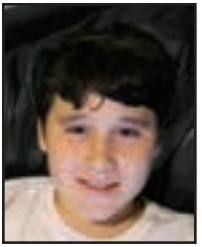
ScentIt: Digitally Recreating Smells

Project Background: Mihir's parents are from India, where he and his family often travel. "I enjoy the unique sights and smells, but end up missing them once we come back home," he says. Weekly video calls with his grandparents back in India let Mihir see what he's missing—like their garden. "While I enjoyed being able to see it, I wondered about being able to smell it as well," he says. Mihir knew smell triggers memories like no other sense. He also realized computers involve our using vision, hearing and touch—but not smell. Mihir started to explore ways of adding smells to make any digital experience richer and more interactive.

Tactics and Results: Mihir decided to create a way of linking specific scents to particular moments in a short movie. He split the project into three phases. He began by creating a scent synthesizer—five microchip-based air fresheners, each linked to a microprocessor. To control the air fresheners, Mihir modified their circuitry so they would respond to signals from the microprocessor. He then programmed the microprocessor so it would interpret signals sent via computer. Mihir next built a library to build and send those instructions. And last, he used the library to create a movie editor. It would command scents to be released at precise points (and from precise locations) during his movie clip. For example, the device released a cinnamon scent during an ad for cinnamon rolls. "This is truly the interactive experience of the future, and my project is a step towards making this a reality," Mihir says.

Other Interests: Mihir enjoys technology, particularly robotics and programming. "They allow me to create something useful that solves a real problem," says Mihir, who created a scheduling app used by more than 900 of his schoolmates. Mihir also likes bicycling, playing cricket and practicing karate. (He's a third degree black belt.)

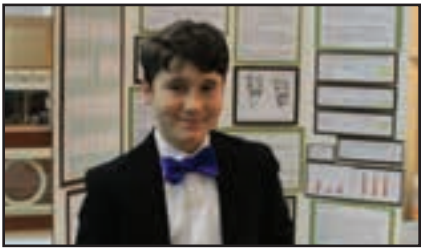
Career Interest: Robotics engineer. "I've long been fascinated by robots. I enjoy working with hardware and software, and one thing that excites me about robotics is that it is at the intersection of these two fields," Mihir says. He finds artificial intelligence especially intriguing, whether in self-driving cars or robot-automated factories.



Caleb A.T. Gonser, 13
Terre Haute, Indiana

Space vs. No Space: Competition for Oviposition Sites in Bean Beetles

Project Background: "Evolution predicts that parents should try to create the best environments for their offspring," Caleb says. Caleb's parents certainly do that to encourage his interest in science. In the summer, he helps the two professors conduct field research on sparrows. And Caleb sometimes attends his mother's classes, including one on the biology of sex and love. In fact, she inspired Caleb's ongoing project. Last year, Caleb examined whether bean beetles preferred to lay their eggs on small or large mung beans. This year, he expanded that study to look at competition. "I hypothesized that female bean beetles would prefer to lay their eggs on beans without eggs," Caleb says.



Tactics and Results: Caleb again experimented on the bean beetle, an agricultural pest in Africa and Asia. Caleb previously found females preferred to lay their eggs on large mung beans. They supplied more energy to beetle larvae. This year, Caleb returned to the biology lab at Indiana State University to learn more. He paired off large and small beans. In one mixed pair, the large bean bore beetle eggs. In the other, the small bean did. As a control, Caleb paired equal-sized beans, one with and one without eggs. He hypothesized the beetles would prefer to lay their eggs on beans without eggs, regardless of size. That choice would provide larvae with more nutrients and less competition. Tests showed females did prefer beans with no eggs. They also laid more eggs on those beans. "Competition between her own larvae does not seem to be as important as competition with the larvae from other females," Caleb concludes.

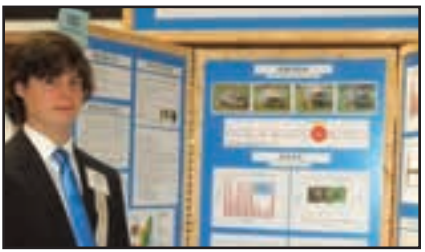
Other Interests: Caleb really likes sports, including basketball and tennis. He is part of the Olympic development program for soccer and made the all-state team in Cal Ripken baseball. He takes piano lessons and plays trombone in band. Caleb also likes animals, including his two cats, dog and iguana.

Career of Interest: Physical Therapist. As much as Caleb enjoys sports, he knows you can't count on turning professional. He could be a physical therapist for a professional sports team, however. "This career could allow me to keep my interest in sports. I will be helping athletes play again after an injury," he explains.

River C. Grace, 14
West Melbourne, Florida

Rain Dance of the Radiata: Behavior of the Endangered Radiated Tortoise and Related Species

Project Background: River grew up surrounded by tortoises, some rare and endangered. "This led me to becoming fascinated by many of their behaviors and need for conservation," says River, who volunteers at the Brevard Zoo. He also spends time at a tortoise breeding facility associated with the Florida Institute of Technology. There, River works with a captive population of radiated tortoises, a critically endangered species from Madagascar. Whenever it rained, River noticed the rare tortoises would rise up and shuffle rhythmically. The dance is little-studied and unknown in other tortoise species. "Fascinated, I devised a series of experiments to test this behavior, with the goal of supporting conservation," River says.



Tactics and Results: "I hypothesized that this behavior allows tortoises to avoid drowning in flash-floods in their arid native habitat," River says of the rain dance. A series of experiments on roughly a dozen of the tortoises would test this hypothesis. First, River sought and received permission to work with the rare species. Next, as a control, he sprinkled the tortoises with water. River measured how long the dance took to begin and its duration. Then he repeated the experiment. He alternately exposed the tortoises to a gentle flow of water, light mist and a sprinkling of lentils. He also placed the tortoises in a shallow pool, to simulate a flood. River even played a recording of falling rain. In each case, the tortoises either danced less or not at all, compared to the control. That suggested the dance had nothing to do with flooding. River now plans to repeat the experiment on several closely related tortoise species.

Other Interests: River enjoys many activities, all of them "interesting, entertaining and productive." He plays classical piano, combining logic and creativity. He also participates in various math teams, allowing him to be competitive doing something he loves. And River is a member of Beta Beta Beta, the national biological honor society.

Career Interest: Physiologist. "As a scientifically minded person, I already love studying how life works, but being able to do experimental physiology as a professional scientist would be incredible," River says. While interested in the ways healthy animals function, River is also fascinated by the physiology of disease.

Seamus Hoolahan, 13
Anaconda, Montana

Feel the Power

Project Background: Seamus worked with a partner after his father suggested the two build a Gauss rifle (Gauss is the unit used to measure a magnetic field). The partners watched several Internet videos that showed how the technology relies on a magnetic chain reaction to launch a ball bearing projectile at high velocity. "We though it might be possible to create a more efficient and effective design," Seamus says. Such a discovery could lead to the creation of non-lethal magnetic guns, they hoped. Their hypothesis was that fewer stages would allow a projectile to travel farther. The partners gathered steel balls, wooden dowels, strong neodymium magnets and clean cat litter and began experimenting.

Tactics and Results: The partners built a simple Gauss rifle. They attached neodymium magnets at regular distances along a rail made from two wooden dowels. They placed two steel balls on one side of each magnet stage. The partners then rolled a steel ball toward the other side of the first magnet stage. The ball accelerated toward the magnets, striking them. The ball transferred its momentum to the outside ball on the stage's far side. That ball rolled toward stage 2 and so on. The last ball was the projectile. (It safely landed in box of cat litter.) The partners repeated the experiment with one to four stages. Each time, they measured how far the projectile traveled and calculated its velocity. "Our conclusion was the opposite of our hypothesis," says Seamus. He explains how the conservation of momentum allowed each stage to add kinetic energy to the rolling ball.

Other Interests: Seamus enjoys band, community theater and sports. He also likes volunteering and participating in academic competitions. "I enjoy these things because they give me a sense of being part of a team where each person plays their own individual part," Seamus says.

Career Interest: Chemical Engineer. "Although there is a lot about being either a chemical engineer or a chemist that I don't yet understand, I like the concept of combining two or more elements to create an entirely new substance," says Seamus. The career would combine his favorite and second-favorite subjects, math and science, respectively.

Krystal Horton, 11
Menifee, California

Agrilus coxalis: The Gold Spotted Oak Borer

Project Background: Krystal loves nature. That made reading the newspaper article especially painful. It reported that a beetle called the goldspotted oak borer was killing thousands of trees in nearby San Diego County. "I just HAD to do something about this," Krystal says. She contacted a local expert and toured his university laboratory. The scientist taught her how to recognize an infected tree. She underwent training, twice, to learn more. She then reviewed a 2008 aerial survey that mapped the infestation. Krystal wondered whether it had worsened or even spread. "I decided to do my own survey (from the ground)," says Krystal. Soon she was off examining thousands of trees for signs of beetle infestation.

Tactics and Results: Krystal downloaded the U.S. Department of Agriculture maps that showed how many trees per acre the beetle had killed in San Diego County. She then visited those areas and counted dead trees. She knew a natural predator of the beetle controlled the pest in some places. She hypothesized if the parasitic wasp lived in the San Diego area, then the infestation would not have worsened. Krystal attended workshops, interviewed experts, watched videos and examined photographs to recognize the signs of infection. It turned out to be harder than she thought. Krystal observed thousands of oak trees over several months. She tracked her movements using GPS and used those measurements to calculate how many acres of trees she had observed. "When I compared these numbers to the USDA numbers, the dead trees per acre had skyrocketed at every single location," Krystal says. That suggested a parasite probably wasn't keeping the beetle under control.

Other Interests: Krystal loves learning how to program computers. She uses Python and Scratch to program her Raspberry Pi, a stripped-down Linux computer. Krystal also builds robots, including a gyroscope-stabilized Lego robot. Krystal blogs, tweets and creates online videos to highlight her science adventures. And she plays flute in her school's symphonic band.

Career Interest: Computer Security Specialist. "I enjoy writing code and setting up technology and that's exactly what a CSS does. This career could be perfect for me," Krystal says. She knows how common viruses and hackers have become. "Computer Security Specialists help stop them and computer forensics helps catch them," she says.

Dhruv Iyer, 15
Chandler, Arizona

From the Playground to the Boardroom: Modified R-P-S Game as a Model for Negotiations with Constraints

Project Background: Dhruv often negotiates with his father, who prefers to avoid conflict. "His motto is, 'If you can make a case, it's yours. If you can't, then it's not,'" says Dhruv. "As a result, negotiations have become a big part of my life." Dhruv and his father often rely on the same old arguments. Some arguments seemed better than others. Dhruv found evidence of a pattern and decided to detect it. He would model negotiations using the game rock-paper-scissors. He wanted to predict the outcome if one player negotiated with constraints—and the other player exploited those limits. "Negotiators need to know to what degree their constraints handicap them," Dhruv explains.

Tactics and Results: In playing rock-paper-scissors over and over, Dhruv would test five constraints. One constraint would require a negotiator to play rock, paper or scissors in a fixed ratio against the other negotiator. Dhruv predicted that would be the most limiting. He then got playing. Dhruv used a computer simulation he wrote to play rock-paper-scissors 100 million times on his laptop. It took just minutes. To see the effect of the constraints, Dhruv used a payoff matrix. In rows and columns, it showed each player's options along with the respective gain (or loss) of playing that way. The simulations disproved his hypothesis. Dhruv found the best strategy is to have no strategy—and just play randomly, or close to randomly. "The paramount thing which I took away from this project is that our daily interactions can be modeled as game, and the results can be predicted using a computer simulation," Dhruv says.

Other Interests: Dhruv enjoys programming and robotics—it's fun, interesting and provides opportunities to learn. He even coaches a robotics camp for under-served children. Dhruv recently bought a smart phone that can remotely control the robots he is now building. He also likes rock climbing, golf and karate.

Career Interests: Software Engineer. "To me, nothing is unlimited. That is, except for the power of computers," Dhruv says. He has a passion and joy for computers. Dhruv is also practical. He knows there will be more jobs for software engineers in the future than there will be students to fill those jobs.

Cameron Jones, 12
Portola Valley, California

We're Jammin': Using the Jamming Principle to Construct a Universal Gripper

Project Background: Unlike human hands, robot hands have a hard time gripping arbitrarily shaped objects. It takes careful positioning, precise maneuvering and complex software. That's why Cameron found the scientific paper so exciting. It described a universal gripper that didn't require any of these things. It didn't even need fingers. Instead the gripper used an elastic bag filled with a granular material. When under pressure, the grains in the material flowed around almost any object. Under vacuum, the grains jammed together. That stiffened the gripper enough to delicately grasp (but firmly hold) an object. "When I discovered the idea, I thought I might be able to improve the concept," Cameron says.

Tactics and Results: Cameron's better gripper uses a computer-controlled vacuum system. It pressurizes and depressurizes a latex balloon filled with coffee grounds. An air reservoir speeds up the gripper's grasp and release. The system includes a pump, multiple valves, power circuit and Arduino microcontroller. A single push of a button triggers the electronically controlled valves to open or close in sequence. That prepares the gripper to grasp or release an object. Cameron tested the gripper by having it pick up a ping-pong ball, brass rod or wooden block. After each test, he dangled more and more weights to the object until the gripper could no longer hold it. Those tests showed Cameron's gripper wasn't just inexpensive to make or easy to program. The tests also showed the gripper worked, and well. "My gripper is capable of reliably picking up a variety of different sizes, weights and shapes without having any prior information," Cameron says.

Other Interests: One of Cameron's passions is programming, including in C, the language he used in his project. He enjoys tennis and plays saxophone in his school band. Cameron likes lots of different types of music. He's even composed some dubstep on his own.

Career Interest: Computer Scientist. Cameron likes this career because it would allow him to do research and create things with code. "It is interesting to see some text turn into an amazing website or game," he says. Cameron already helps his teachers and classmates with computer problems.

Johann Kailey-Steiner, 13
Denver, Colorado

Rocket Design Part 3 - Exploring How Vortex Generators Affect Boundary Layer Airflow

Project Background: Johann has his eye on the sky. He wants to become a pilot, just like his parents. Johann has also thought of becoming an astronaut. So it's no wonder he likes experimenting with model rockets. Drag slows a rocket as it moves through the air. Reducing drag helps rockets fly higher and faster. In earlier experiments, Johann added tiny blades, called vortex generators, to his rockets to reduce drag. For this experiment, he wanted to find out why the vortex generators reduced drag, and at what speeds. His ultimate goal: Engineering a device to extend the blades from a model rocket precisely when they could do the most good.

Tactics and Results: A professor let Johann test his rockets in a university wind tunnel. Johann built them from scratch. For his first test, Johann positioned the rocket parallel to the wind. He recorded drag and other measurements at a range of speeds, with and without vortex generators. He found the blades added drag at all speeds. That contradicted his earlier results. Rather than be discouraged, Johann built another rocket and did more tests. This time, he found the vortex generators did reduce drag but only when the rocket was slightly angled to the wind. Johann knew that could occur to a model rocket after its engine stopped burning. "I decided, based on my data, that I should create a device to extend the vortex generators after engine cutoff," says Johann, who did just that. His mechanism works on command to push the vortex generators out of slits cut into the rocket body.

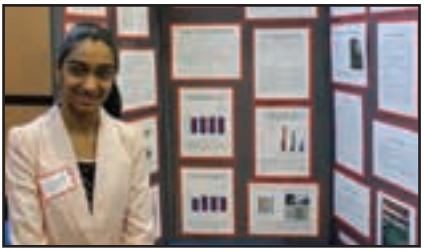
Other Interests: "My favorite hobby is inventing," says Johann. He has built everything from remote-controlled cars to pogo sticks and boomerangs. He is an expert skier, and enjoys basketball, baseball and soccer too. Johann's played piano since age 3. He plays jazz and writes his own songs. Oh, and he's already taken some flying lessons.

Career Interest: Physicist. "Physics describes the universe and I am interested in finding answers to questions that human beings have about the world," Johann says. For now, he is undecided about pursuing quantum, theoretical or astrophysics.

Rhea Kamat, 14
San Antonio, Texas

Broccoli Power: Effect of Sulforaphane on Tadpole Development

Project Background: Rhea heard from her parents what kids everywhere hear: "Eat your broccoli. It's good for you." Wary, Rhea checked out their claim. To great surprise, her research revealed that scientists are studying a key broccoli ingredient called sulforaphane as a treatment for lung and other diseases. That grabbed Rhea's interest, since she suffers from asthma. "Hence, I decided to investigate if sulforaphane would accelerate lung development," Rhea says. She hoped her findings could help steer further research into using sulforaphane in treating premature babies and young children with underdeveloped lungs. Rhea began designing an experiment using some even smaller subjects—tadpoles. She would study if sulforaphane sped along their development.



Tactics and Results: Instead of tadpole lung growth, Rhea studied a related development: the sprouting of their hind limbs as they grew into bullfrogs. She created four groups of nine tadpoles. Each tadpole got its own container filled with 500 milliliters of water. Three of the groups received twice-weekly doses of either 100, 200 or 400 micrograms of sulforaphane (broccoli extract). A fourth group, the control, got none. Once a week, Rhea measured and weighed the tadpoles. She also watched for the sprouting of their hind legs. That stage coincides with early lung development. By Week 3, anywhere from 22 percent to 56 percent of the tadpoles given sulforaphane had started developing hind limbs. In the control group, none had. "Results of my study support my hypothesis as sulforaphane increased the rate of development," says Rhea. She notes that 100 micrograms appeared to be the optimal sulforaphane concentration.

Other Interests: Rhea loves cooking, especially turning mundane ingredients into something unique and tasty. She also transforms herself, when performing classical dance or drama in character. "I enjoy entertaining people, and dancing and acting allows me to communicate with my audience and build a bond with them through my performance," Rhea says.

Career Interest: Immunologist. "Interacting and treating people of different ages and walks of life for debilitating autoimmune diseases like multiple sclerosis, and simultaneously studying the highly complex immune system to find a cure that will significantly change their lives will be a very rewarding career," Rhea says.

Austin McCoy, 13
Rochester, Minnesota

Designing and Validating Affordable, High Quality Polymerase Chain Reaction (PCR) Laboratory Equipment for Developing Nations

Project Background: Austin learned from a mentor how disease outbreaks kill many people in countries too poor to afford necessary detection equipment. That motivated Austin to apply his science, technology, engineering and math skills to saving lives. He learned more about how early detection is crucial in controlling outbreaks of diseases, including dengue virus. Diagnostic tests for dengue require making billions of copies of viral DNA segments. The process uses a tool called polymerase chain reaction (PCR). It also requires using an expensive machine called a thermocycler—or doing it by hand. The hand method is inexpensive but complicated. So Austin invented a way to automate it.

Tactics and Results: PCR requires repeatedly heating and cooling DNA samples, by machine or hand. Austin used inexpensive technology and some custom algorithms to create an automated, affordable and reliable alternative to the manual method. Austin's first engineering design didn't work. His second design included a microcontroller, pumps, valves, thermometers, scrap insulation and a $4 bucket. It had to raise the temperature of the test tubes holding the DNA fragments, and then rapidly lower it by as much as 20 degrees Celsius. Austin programmed the device to mix hot and cold water in the proper ratios. That could yield just the right temperatures over multiple cycles. He also developed algorithms to compensate for heat loss in the hoses, and for any cooling while the test tubes soaked. "Even though it is not yet a finished product, my thermocycler has met all of the most difficult engineering requirements," says Austin, who's now building an even better version.

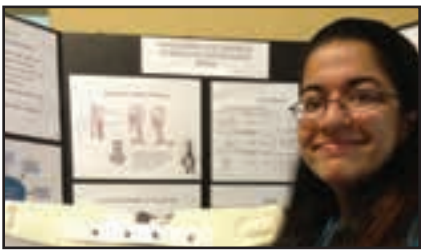
Other Interests: Austin likes to make a difference. He has volunteered at camps, nursing homes and food pantries. He also likes robotics and programming. His favorite hobbies are making (and playing) video games and movies. "I enjoy these activities because I can be creative and imaginative," Austin says.

Career Interest: Bioinformatics Scientist. "Bioinformatics is fascinating to me because it involves biology, computer science and information technology; all areas that I greatly enjoy," Austin says. He also likes that it could lead to discoveries that save lives.

Smita Mohindra, 13
Yorktown Heights, New York

Novel Strategies in the Treatment of Vertebrobasilar Insufficiency Using Sensors

Project Background: Last year, Smita's grandfather was reaching for the microwave when he stretched and twisted his neck. "As he was doing so, he felt very weak and dizzy and quickly fell, hitting his head on the kitchen floor," Smita says. His movement had pinched a clogged artery in his neck. That choked the flow of blood and oxygen to the rear of his brain, causing a condition called vertebrobasilar insufficiency, or VBI. Luckily, her grandfather survived. However, later tests revealed the condition had caused him to suffer a mini stroke. "Watching him and many others suffer from VBI served as a major source of inspiration for my research," Smita says.



Tactics and Results: Smita wanted to help others at risk for VBI. She learned that the condition is usually treated with surgery or drugs. Smita sought an alternative that didn't enter the body. She hypothesized that a soft collar fitted with five touch sensors and a buzzing alarm could help. It would warn a wearer of any excessive twisting and stretching—the kinds of neck motion that can lead to VBI. Smita developed a baseline range of neck motions by measuring family members. She interviewed medical experts and read scientific papers. And Smita soldered together the collar's touch sensors—a technology she had learned about in FIRST Lego League. "My prior knowledge of working with touch sensors while making robots helped me to find a novel, non-invasive solution to VBI, which was also both comfortable and portable," Smita says. Further experiments will verify if her working prototype can prevent VBI in high-risk patients.

Other Interests: Smita has a silver award in Girl Scouts, and sings in a Scout choral group. Smita likes to read science fiction and to play tennis. And she plays the double bass in her school orchestra. "I find that playing an instrument enhances coordination and mathematical skills," Smita says.

Career Interest: Biomedical Engineer. Smita wants to use engineering to solve medical problems. "The devices created are used to help people in need of treatments, and I would love to be a part of enabling someone to do a particular thing that they had not been able to do before," Smita says.

Caroline Nolan, 13
Stuart, Florida

Bee Happy, Bee Healthy: Improving the Health of Bee Hives

Project Background: Each year, disease and other factors destroy about one-third of honeybee colonies. "The honey bee population is rapidly declining," Caroline says. That threatens the $15 billion job that bees do for people: Pollinating fruit, vegetable, nut and other crops. Caroline worries if bees vanish, it would have a huge impact globally. "I really wanted to research ideas that could help to save the bees," she says. First, she had to become a beekeeper. She enrolled in a beekeeping course offered by her county extension office. "When the apiary gate was opened, it seemed like a million bees were flying around," Caroline says. "I wanted to run away. I didn't."

Tactics and Methods: If honeybees worked less, they would be healthier, Caroline thought. Bees fan their wings to keep hives cool and dry. She hypothesized that adding ventilators would reduce hive temperature and humidity. The bees could spend more time tending their larva, collecting pollen and making honey. Caroline built six hives from scratch. She added solar-powered ventilators to two hives and AC-powered ventilators to another two. The last two hives were controls. Caroline automatically tracked the temperature and humidity in all six hives. She then measured hive health using different factors. Bees living in the ventilated hives collected more pollen and had no sign of mite infestation. Those hives also increased most in mass, adding more bees and honey. Caroline measured activity too, spending hours counting bees. Honey from the ventilated hives also had lower moisture content—and received the highest rating from a state honey show judge. "Therefore," Caroline concludes, "ventilators do benefit honeybees."

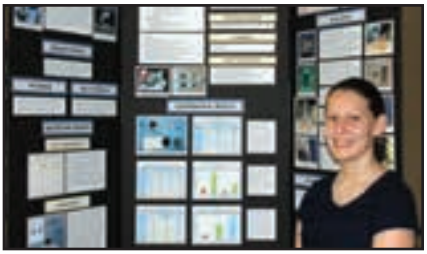
Other Interests: "Reading is my favorite hobby," says Caroline. Her personal library contains more than 1,000 volumes. Books lead her in interesting directions: The Secret Life of Bees, a 2002 novel, inspired her project. And a comic book motivated Caroline to earn her extra-class amateur radio operator's license.

Career Interest: Pilot. Caroline recently flew in a small plane. "I really enjoyed the flight, but had not thought about it as a career choice," she says. Some further research got Caroline thinking about how flying would combine her love for travel, science and math.

Julienne Sauer, 14
San Ramon, California

Quantum Locking: The Future of Frictionless Motion

Project Background: Cool down a superconductor, place it in a magnetic field and it will levitate. It's a powerful sight. Experts would like to use the remarkable properties of superconductors for many things. Imagine a levitating train that could zip along, frictionless, above its track. Of course, superconductors would have to be large enough to support a lot of weight. Julienne saw an online video in which a scientist explained how even a palm-sized superconductor theoretically could hold up a small car. That got her thinking about the different sizes and types of superconductors now available. She wondered how much weight those superconductors could hold when levitating using either of two techniques.



Tactics and Results: Julienne researched superconductors. She contacted scientists with questions. Local companies provided superconducting discs, and the liquid nitrogen to cool them. "When the cooled superconductor levitated the first time right before my eyes, I let out a loud scream!" says Julienne. "My curiosity then took over and encouraged me to explore quantum physics even further." Julienne decided to test two different superconducting materials, in 0.5- and 1-inch discs. She also would test two techniques, Meissner effect and quantum locking. The Meissner effect relies on the superconductor's expulsion of a magnetic field to levitate. Quantum locking allows the magnetic field to penetrate the superconductor, pinning it in place. Julienne took turns adding balls of aluminum and grains of sand to each disc until it sank under the weight. Julienne's statistical analysis confirmed her hypothesis: The larger bismuth strontium calcium copper oxide disc, using quantum locking, held the most weight.

Other Interests: Julienne enjoys learning about history, playing clarinet in her school band, playing soccer and swimming. She also volunteers at the local animal shelter. Julienne takes care of dogs awaiting adoption. She collects old towels, dog food and even cash to help out the shelter.

Career Interest: Forensic Anthropologist. Julienne would like to specialize in facial reconstruction or skeletal analysis. She knows the work involves smells, bugs and other unthinkables. "Emotionally I would witness many sad stories, but I believe it would be exciting to become a detective and figure out the story behind a skeleton," Julienne says.

Nathaniel Sperry, 14
Falls Church, Virginia

When Carrots Turn Green... Literally!

Project Background: Carrot cakes are a birthday tradition in Nathaniel's family. Family members can always expect the same kind of cake. They also can expect an unusual but now familiar surprise too. The carrots going into the cake are always orange. But when it comes time to slice into the finished cake, some carrot pieces always manage to mysteriously turn green. "The experience of seeing carrot pieces turn green in our family birthday cakes, cake after cake, year after year, was so intriguing that I decided I had to investigate it for my science fair project," Nathaniel says. Combining different ingredients—chemistry and robotics—helped him turn up some answers.

Tactics and Results: Nathaniel discovered the green carrot problem was well-known. Food bloggers usually blamed baking soda, without scientifically testing the theory. Nathaniel hypothesized increased baking soda levels would turn more carrots green. He baked three cakes each with zero, ¾ or 1½ teaspoons of baking soda. He then separated out the green pieces and objectively verified their color using a colorimeter built using Lego Mindstorms. The cakes without baking soda had no green carrots. The normal cakes contained some. However, the cakes with twice the baking soda contained even fewer green carrots. Hypothesis refuted. More research suggested anthocyanin in the carrots was to blame. The pigment changes color under different pH conditions. It is pinkish when acidic, greenish-bluish when slightly basic, and yellow when basic. Baking soda is basic. That explained why normal amounts of the cake ingredient turned some carrots green—but too much baking soda (or none at all) had little or no effect.

Other Interests: Nathaniel says Math Olympiad is an enjoyable challenge. He likes playing French horn in band and competing in FIRST Lego League. Nathaniel has reached the rank of Star in Boy Scouts. And he plays tennis and participates in the John Hopkins Center for Talented Youth.

Career Interest: Computer Programmer. "I would choose this occupation because I would like the learning opportunities it presents, and it would be neat and satisfying to be able to change a program to do just what I wanted," Nathaniel says. It would also be fun—something he's already learned programming Lego Robotics.

Hannah Steele, 13
Bedford, Virginia

What's the Interplanetary Forecast: Can a Homemade Magnetometer Accurately Measure How the Interplanetary Magnetic Field Is Affected by Solar Storms?

Project Background: Watching Star Trek at home inspired Hannah to explore space. Today, she's on her way—while still at home. Hannah used a home built instrument to measure how storms that erupt on the Sun affect Earth. Called solar flares, they fling off magnetic energy that has built up in the Sun's atmosphere. This stormy activity causes small but measurable changes in the direction of Earth's magnetic field at its surface. Hannah learned how scientists use an instrument called a magnetometer—basically a sensitive compass—to monitor solar storms. (Experts worry the storms might damage electronics inside communications, GPS and other satellites.) Then Hannah built her own magnetometer and began monitoring the solar weather from home.

Tactics and Results: Hannah hypothesized her instrument would produce results similar to the measurements made by government instruments 75% of the time over a five-day period. She used a borrowed commercial magnetic field detector as a control. Hannah's magnetometer consisted of twin magnets attached to a taut vertical thread. She shined a laser at a mirror attached above the magnets. Hannah positioned a light detector where the mirror reflected the laser. Under normal conditions, the magnets pointed like a compass to the magnetic north pole. A solar storm would deflect the magnets—and the mirror. Her light detector would be sensitive to those changes in the reflected light. A computer interface collected data from the home built and commercial instruments every 30 minutes. Hannah analyzed her results. The data collected by the three separate instruments correlated. "My magnetometer was able to accurately measure the fluctuations of the interplanetary magnetic field better than planned," she says.

Other Interests: Hannah likes activities that combine competition and teamwork. She plays (and coaches) soccer. Hannah also participates in Odyssey of the Mind and other extracurricular academic activities. She writes for the local paper too. "This is a unique opportunity I have taken advantage of by writing one article every six months," Hannah says.

Career Interest: Chemist. "It looks like a lot of fun to freely experiment with chemicals to develop new ideas or products," says Hannah. One such product she would like to invent is an effective treatment for the rheumatoid arthritis that causes her mother extreme pain.

Megan Swintosky, 14
Hatfield, Pennsylvania

Novel Mutations in the FLCN Gene in Cases of Familial Spontaneous Pneumothoraces

Project Background: Though rare, a genetic condition passed down through Megan's grandfather is common in her family. Called spontaneous pneumothorax (SP), it happens when air sacs on the surface of the lung burst. The air leaks into the space between the lung and chest. That air puts pressure on the lung. It can partially or completely collapse the lung. "When I learned that this condition could be fatal, I was determined to prevent that from ever happening to my family," Megan says. Megan knew mutations in the folliculin gene were sometimes linked to the condition. Since the 1-in-100,000 condition affected six members of Megan's family, she hypothesized a genetic mutation was responsible.

Tactics and Results: Megan collected DNA samples from 19 members of her family, representing three generations. Working in a university laboratory, Megan struggled to amplify, or make copies, of the DNA. "I learned… you have to work hard to get results." She then sequenced the DNA. That means she read out the exact order of its letters—each A, T, G and C. Megan then compared the readouts to a control sample, focusing on the folliculin gene. (The gene contains instructions for a protein found in lung tissues.) The comparison would reveal any genetic mutations, including those found in one or both copies of a relative's gene. "I found a new mutation (not previously reported) in 17 out of the 19 subjects I tested in my family," Megan says of her two-year project. "This led to further proof that my mutation very well could have caused the SPs in my family."

Other Interests: Megan likes drawing, reading, music and sports. "I'm good at them, and enjoy the exercise." She also collects rocks. Depending on how they look, Megan cracks open her samples to look for crystallization. "I enjoy this because of my curiosity and respect for the beauty of nature," she says.

Career Interest: Chemist. "I enjoy science as a whole, but especially hands-on lab experiments that include chemical reactions," Megan says. Reactions, such as putting a flame to a copper mineral salt, in particular fascinate her. She already dreams of using her curiosity to unveil something new and beneficial to society.

Brenna Wallin, 13
Lexington, Kentucky

Nuclear Nerka: Detection of Ionic Radiation in Pacific Sockeye Salmon

Project Background: The Fukushima nuclear power plant disaster leaked radiation into the Pacific Ocean. Brenna read articles about cesium 137 contaminating the water—and fish. She worried about her family's health. After all, they ate salmon every week. Research showed her how the plume of radiation from Fukushima intersected the migratory routes of the Pacific sockeye salmon *(Oncorhynchus nerka)*. The fish is often sold in American grocery stores. "I thought that I should do research in this area because if their fish are contaminated then ours might be as well," Brenna says. She hypothesized that wild-caught Pacific sockeye salmon would have more ionizing radiation than farm-raised Atlantic salmon. Testing the fish would tell.

Tactics and Results: Brenna wanted to buy a $3,500 commercial ion detector. Her father said no. "He said I had to build one myself if I wanted to do this project," Brenna says. She built one by modifying plans found on the Internet. Her finished instrument combined a coffee can with various components, including transistors. It measured how any ionizing radiation made the air electrically conductive. (The transistors amplified the very small currents produced by radiation.) Brenna's father did buy something: Samples of wild-caught Pacific sockeye from three Alaska fisheries, and Atlantic salmon from fish farms in Chile, Florida and Scotland. Potassium chloride served as a radiation target. The salt substitute emits low levels of ionic radiation. Detecting that radiation confirmed the instrument's sensitivity. Brenna then tested her salmon samples. "After extensive testing, my data showed my hypothesis to be true," she says. "Pacific salmon has more ionic radioactivity than farm-raised Atlantic salmon."

Other Interests: Brenna has played soccer since she was 4 and recently joined an elite team. She also collects rocks and coins. "I like to investigate what they are, where they came from and how valuable they are," she says. Brenna hopes to enter her pet rabbit in next year's Kentucky state fair.

Career Interest: Neurologist. "I would like to help people with brain injuries and other types of neurological problems. My sister has migraine headaches. She recently received an MRI. This technology is amazing to me. I would love to learn how it works and how to use it to help people," Brenna says.

Sean Weber, 13
Sequim, Washington

Strength of Mussel Byssal Threads Versus Wave Action

Project Background: Sean's interest in mussels comes from living on the Strait of Juan de Fuca, in Washington State. There, impressive numbers of the shellfish cling tightly to rocks washed by the waves. Some mussels attach themselves to the side of rocks facing the open water—and the waves. Other mussels latch onto the sheltered side, facing shore. Sean knew from a mentor that mussels anchor themselves using elastic but tough filaments called byssal threads. His project would determine whether blue mussels *(Mytilus edulis)* adapted to living on rocks exposed to heavy wave action. The results would also show how mussels adapted—and whether the chemistry of byssal threads made a difference.

Tactics and Results: Sean hypothesized the wave-facing mussels and their individual threads both formed stronger attachments. Their elemental composition would explain the variations, Sean thought. He used a spring scale to pull mussels from the rocks, measuring their attachment strength. (Sean switched to blue mussels after California mussels took more than the maximum 25 pounds of force his scale measured.) Sean pulled off 24 mussels: equal numbers from sheltered and unsheltered locations. He measured the mussels. Sean also measured and counted their byssal threads. Sean then determined the tensional strength of single threads. A mentor at a local marine science laboratory determined their chemistry. The statistically significant results of Sean's tests confirmed his hypothesis. It took 53% more force to dislodge unsheltered mussels. Those mussels also had 50% more byssal thread attachments—and those threads required 59% more force to break. The threads also were longer, and contained more iron and calcium.

Other Interests: Sean has a Star rank in Boy Scouts. He enjoys hiking, backpacking, practicing first aid and collecting specimens. Sean also volunteers at his local library. And he plays select soccer. "No matter what I try, the most important thing is that I do my best and learn something from it," he says.

Career Interest: Neurologist. "I find the field of neurology very important; every time we breathe, think, move, sense or feel, it's all caused by our nervous system and brain," says Sean. He would like the opportunity to work hard at a job that requires him to be observant, analytical and communicative.

Joshua Wentzel, 14
Portland, Oregon

Going Ballistic! The Surprising Relationship of Reservoir Volume to Barrel Length and Reservoir Pressure in a Homemade Air Cannon

Project Background: Two years ago, Joshua built a water rocket launcher for a science project. An episode of *MythBusters* inspired his next project: an air cannon. "Wow! I want to build one of those," Joshua thought. He did, and began experimenting with projectile shape. He then began to experiment with how different variables would affect the velocity of a golf ball projectile. Joshua used hardware store parts to build his air cannon. The design let him vary the volume and the pressure of his air reservoir. He also could adjust the muzzle length. Joshua knew the three variables each would have an effect. What he didn't know was how the variables would interact.

Tactics and Results: Joshua hypothesized increased reservoir pressure, reservoir volume or barrel length each would increase the velocity of a golf ball shot from the muzzle. He used different lengths of PVC tubing to create the barrel and the air reservoir. A sprinkler valve joined the two components. (The design made it easy to swap out different reservoirs and barrels.) A bike pump pressurized his cannon, and a chronograph measured projectile velocity. Joshua realized controlling temperature, humidity and other variables improved accuracy. His tests then began giving results. "I found that, within certain limits, for all reservoir volumes and barrel lengths, increasing the reservoir pressure increased the muzzle velocity as long as the reservoir volume and barrel volume were matched," Joshua says. Surprisingly, if reservoir volume was much smaller or larger than barrel volume, more pressure didn't increase velocity. Meanwhile, optimum reservoir volume-to-barrel length ratios varied from reservoir to reservoir, largely unaffected by pressure.

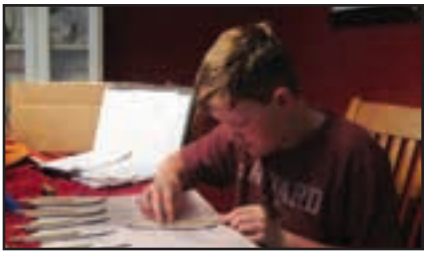
Other Interests: Joshua's two favorite activities are building and programming—something he likes to do with Lego Robotics. He also likes to compete in chess tournaments. It forces him to rapidly analyze situations and develop a strategy. And he thinks on his feet and exercises his knowledge of current events in debate club.

Career Interest: Mechanical Engineer. "This career is interesting because I will get to use my skills to solve problems and possibly invent new things," says Joshua, who likes using tools, computers and math. "This is a career that will engage my brain."

Grant Donovan Womble, 14
Tallahassee, Florida

Blown Away by Biomimicry: Increasing the Efficiency of Wind Turbines Through Biomimicry Enhanced Blade Design

Project Background: The size and shape of the wind turbines Grant saw on a visit to California amazed him. Grant learned how turbine blades are designed to minimize drag, or air resistance. Their design also reduces drag, resulting in the loss of lift. Later, seeing an aquarium exhibit on biomimicry also impressed Grant. There he learned how biomimicry uses technology inspired by nature to solve engineering problems. Grant wondered if nature could inspire more efficient turbine blades. He began learning more about how wings and fins slice through air and water. "I researched the most effective flyers and swimmers in the animal kingdom and designed wind turbine blades to mimic their shape," Grant says.



Tactics and Results: Grant decided to build and test four blades inspired by nature, using a fifth blade as a control. The four blades would mimic the naturally aerodynamic shapes of the albatross, seagull, humpback whale and flying fish. Grant used balsa and dowels to create the uniformly sized blades. Grant hypothesized the blade that mimicked a humpback's bumpy flipper would be most efficient. He also built a wind turbine, and an electric circuit to measure the voltage and amperage the blades produced when turned by a fan's breeze. Grant tested each blade design's power and efficiency at different fan speeds and distances. Analyzing the results confirmed Grant's hypothesis: The humpback blade was best. "Ultimately the experiment taught me that wind energy can be more efficient if we utilize nature as an engineering tool," Grant says. Next, he wants to test more blade shapes with more powerful fans.

Other Interests: "Living in Florida has given me many outdoor opportunities to hike, row, bike, geocache and play sports where nature is my teacher," says Grant. Whatever he's doing, Grant treats it as a chance to expand his knowledge. The pollution he spotted while kayaking once even inspired another science project.

Career Interest: Pediatric Neurologist. Grant's grandmother has Alzheimer's and a cousin was born with mental deficiencies. That has inspired him to learn more about the brain and central nervous system. "I am very curious about how they think and what their disability has done to their minds," Grant says.

Katherine Wu, 13
North Potomac, Maryland

The Association of Selling Sweets/Snacks at School and the Obese Rate at School

Project Background: An overweight relative inspired Katherine's project. The relative constantly tried to lose weight by eating less. "I felt her pain, and wanted to help in any way I could," Katherine says. Her research revealed obesity is increasingly a problem with children. "I hypothesized that banning sweets/snacks at school will decrease the (obesity) rate, because students gain weight when they eat more than they need," Katherine says. Katherine shared her research idea with her science teacher over summer vacation. He replied immediately and said it was a good project on an important topic. He also suggested Katherine use statistics. So she took an eight-week online college class in statistics. Katherine was ready to get started.

Tactics and Results: Katherine first downloaded the results of a huge federal study. It contained age, height, weight and other data on about 10,000 eighth graders from across the country. It also detailed the students' snacking habits, and whether they were trying to gain or lose weight. Katherine wrote a program in Python to sift through the data. She then merged it with growth chart data to highlight obese students. And she contacted officials to identify which schools sold snacks or sweets. Katherine then used her new skills in statistics to examine the association between selling sweets and obesity rates. Unexpectedly, the data refuted her hypothesis: A school's banning non-nutritious food made no statistical difference on obesity rates. To understand why, Katherine looked at what students were doing about their weight. She found the students who were overweight and/or trying to lose weight actually bought snacks less frequently than others.

Other Interests: "I love music and have been playing piano since age 5," says Katherine, who played with the Washington Philharmonic Orchestra after winning a state concerto competition. "Playing piano has taught me anything is possible with hard work. It also lets the fingers follow the heart," she says.

Career Interest: Biostatistician. "Biostatistics interests me because it integrates all my favorite subjects," says Katherine. "Biostatisticians are making data speak, and changing data to knowledge." She would like to use data to find cures for diseases, create new medicines and encourage healthier living.

Index of 2013 Broadcom MASTERS Finalists

The Inspiration for the Broadcom MASTERS

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 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.

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.

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Broadcom Foundation inspires young people throughout the world to enter careers in science, technology, engineering and mathematics (STEM) through partnerships with local schools, colleges, universities and non-profit organizations. The Foundation's mission is to advance education in STEM by funding research, recognizing scholarship and increasing opportunity.

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Society for Science & the Public (SSP) is one of the oldest nonprofit organizations in the U.S. dedicated to public engagement in science and science education. Established in 1921, SSP is a membership society and a leading advocate for the understanding and appreciation of science and the vital role it plays in human advancement.

Through its acclaimed education competitions and its award-winning *Science News* family of publications, SSP is committed to inform, educate, and inspire.

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