



Cycle for Science

www.cycleforscience.org

www.youtube.com/watch?v=Ed4txeUSlks

Gail Oare



Americans headed West in the 1800s in covered wagons for better lives and fortunes. Then in the 1900s, many crossed the country in search of personal adventures of the type mythologized in the 1960s television show *Route 66* and in Jack Kerouac's *On the Road*. Today, trekkers are frequently motivated to cross the continent for the higher purpose of generating support for global social causes, such as medical research. Two young scientists from California recently became members of this elite latter category. Also bicycling enthusiasts, Elizabeth Case and Rachel Woods-Robinson literally put a new spin on social outreach by pedaling the width of the country while engaging hundreds of students along the way in enjoyment of science and appreciation of its potential to solve real-world problems.

Their 3500-mile bike trip began in April 2015 and ended in mid-July in

New York City after 89 days on the road. Prior to their departure, they had developed the title of "Cycle for Science" and adopted the theme of renewable energy to illustrate their message. They then solicited support, scheduled school visits along their path, and designed a solar-driven model bicycle for use in the classroom. Using a three-dimensional (3D) printer, they produced copies of this Sol Cycle that they carried with them for use in the 22 workshops they would conduct at 10 locations in California, Idaho, Wyoming, Iowa, Indiana, Pennsylvania, and New York.

"We planned our workshop for middle-school students," Case said, "but we actually worked with students from ages 4 through 18." Undaunted, they adjusted their lessons as needed to accommodate everyone in the classes.

Their "Cycle for Science" lesson plan started with introductions and a

description of exciting careers in science. Woods-Robinson is a materials researcher and Case is pursuing her PhD degree in mechanical engineering. Next they introduced the concept of 3D printing and its advantages over other manufacturing methods, followed by a brief physics lesson on photovoltaic energy conversion and a discussion of atoms. With older students, they also discussed photons and the concept of particle/wave duality. Then the workshop fun really began.

In a short skit about energy, four students played the roles of the sun, a nucleus of a silicon atom, a low-energy electron orbiting the nucleus, and a motor. In the performance, the sun threw off packets of quantized energy ("role-played" by candy or snack bars). The newly energized electron then broke free of its nucleus until the hungry motor grabbed the energy packets. As the motor began to spin, the sad electron returned to its low-energy state around the nucleus to await the arrival of the next photon.

After role-playing, the students were ready to construct and operate their Sol Cycle. Teams worked to figure out how to attach the motor, where to put the rubber bands to achieve the most efficient gear ratio, and how to connect the alligator clips from the solar panel to the terminals of the motor. "We took them outside, where the kids were able to conduct their own experiments on the Sol Cycles," explained Woods-Robinson. "When a clip came off or short-circuited, or when the training wheels shifted causing the bike to wobble, the students had to assess the problem and fix it themselves."

"Usually" she added, "it would lead to a wild Sol Cycle race."

Each class was then given at least one Sol Cycle so they could continue their work long after the bicycling scientists disappeared over the horizon.



Rachel Woods-Robinson (left) and Elizabeth Case pause at the Grand Tetons at the beginning of month two of their trip. From here they camped at Jenny Lake, rode over Twogottee Pass (and the Great Divide) and on to Casper, Wyo., where they taught a middle-school class.



The workshop was a special experience for the students and they were positive about the things they learned. Many were excited about the concept of 3D printing. Some students who have access to a 3D printer even planned to work on an improved Sol Cycle 2.0. "One of my favorite moments was in Waterloo, Iowa," Woods-Robinson said. "A little girl got so excited about what she could build with a 3D printer that she asked if she could produce 'even a flying pig?'"

The students also came to realize that anyone could be a scientist if they were inquisitive and willing to look at problems such as renewable energy from another perspective. The two scientists acknowledged that they were not intending to convince all the students to become scientists. They did hope, however, that the students would see that science literacy was important for other professions as well, such as lawmakers and economists who are involved in solving major social challenges.

"We taught a group of Burmese refugee students in Philadelphia who didn't know what a 3D printer was. We also had an incredible language barrier with them," Case said. "But by the end of the workshop, it really didn't matter."

Woods-Robinson agreed. "At the end of the lesson," she said, "an eleventh grader who had initially boasted 'I hate science' told us that she was now interested in studying the role of international relations in renewable energy and science."

The hosting teachers likewise were enthusiastic about the experience. Brian Whitney, STEM (science, technology, engineering, and math) specialist at Hidden Springs Elementary in Boise, Idaho, arranged for 60 students to participate in the workshop. "Rachel and Elizabeth covered some basic energy content, infused with a decent dose of higher level questioning and some engaging higher level content as well! They did a great job of compacting a potentially complex topic into a manageable 15-minute lesson prior to the hands-on activities," Whitney said.

"The construction of the solar cycle was a great activity," noted Polly Beebout, science teacher at CY Middle School in



From top left clockwise: Rachel Woods-Robinson helps two participants piece together a Sol Cycle at a library in Indiana. Elizabeth Case prepares the Sol Cycles. Two children work together to re-attach the motor to the solar panel in Pennsylvania.

Casper, Wyo., where Case and Woods-Robinson conducted five workshops and three Career Day sessions. "The students will remember how a solar panel works and the importance of conservation," she said. "It was real-life learning about real-life issues facing our kids."

Other benefits resulted from simply being face to face with the scientists, Whitney said. "Students learned that Rachel and Elizabeth were excited about their work and were fun people. And the fact that they are both female added a silver lining. They are great role models."

For the bicycling scientists, "Cycle for Science" was a fun and satisfying classroom experience as well as an adventure of a lifetime. Prior to the trip, neither of them had undertaken bike trips much longer than 35 miles. "I had no idea what 3500 miles meant," Woods-Robinson said. "I doubted myself."

Case agreed. "It was challenging both physically and mentally."

But the two quickly realized that concentrating on small goals along the way was their key to success. They narrowed their focus to one day and sometimes one mile at a time. They directed their attention to the daily decisions of contending with the thunderstorms they were tracking, achieving their mileage quota, and

determining what they would eat that day and where they would sleep that night. The success of their trip was the sum of these daily achievements.

"Our strategy was not unlike how scientific challenges will need to be tackled in the future," Woods-Robinson said. "It's going to take a series of small, creative advances from curious people like these students to make big changes in our energy infrastructure and in emerging technologies."

"On a personal level, I also found that I faced every day of the trip with joy and gratitude," Case said. "There was rain, hot sun, and road kill, but there were also unbelievable scenery and rainbows. I now want to go backpacking!"

But until then, they will resume their regular lives. Woods-Robinson returns to her work at Lawrence Berkeley National Laboratory and Case to Cornell University to pursue her PhD degree.

They will also enjoy some downtime to reflect on the many great memories of their cross-country adventure. When they look back with satisfaction at the many students they inspired, they will likely remember the fifth grade girl in Boise who told them, "I want to do what you do when I grow up. I want to bike across the country *and* be a scientist!" □



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