

Scientific Outliers

How teachers and students in rural America can learn good science

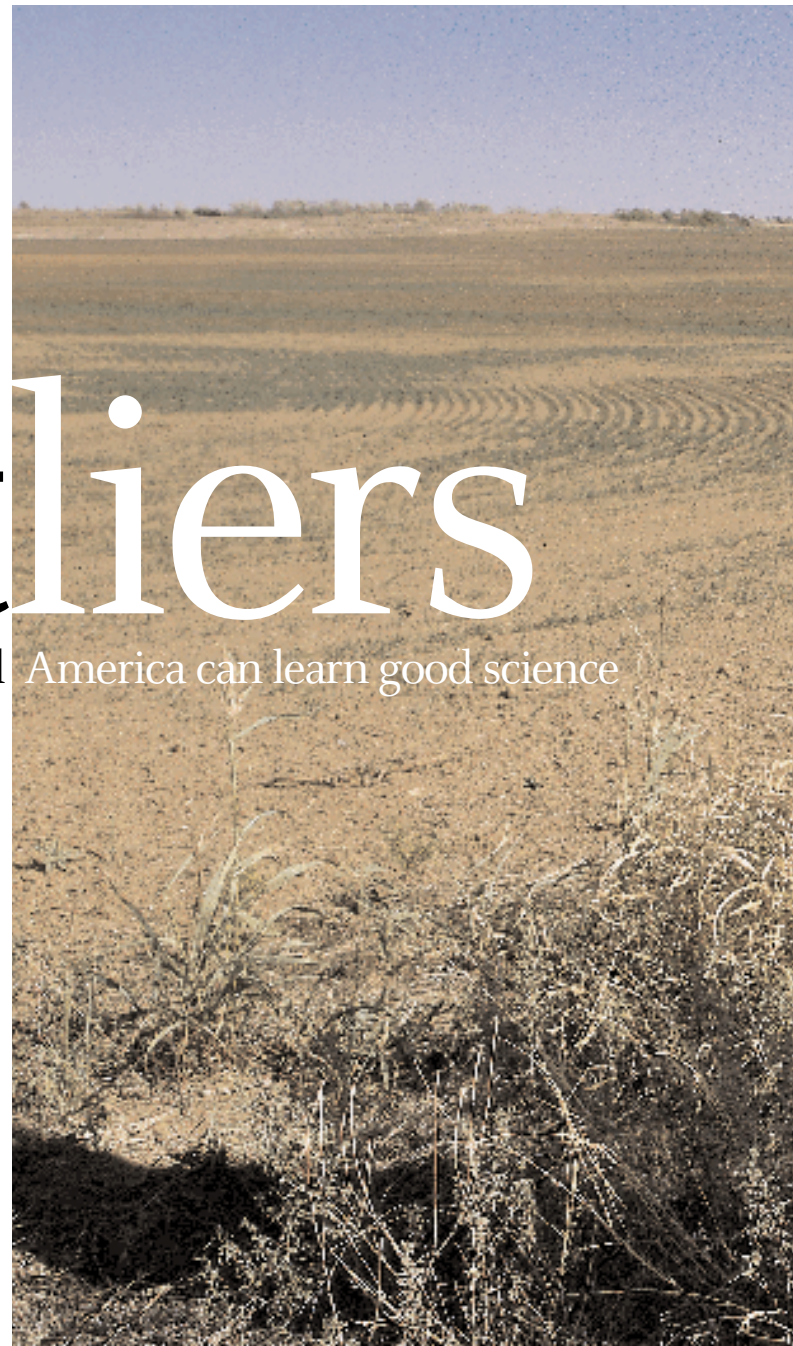
BY MITCH LESLIE

In 1993 Robbie McCarty was fed up, burned out and ready to resign. For six years she had been the lone science teacher at a 300-student school in Duke, a small agricultural town in far southwestern Oklahoma, about a three-hour drive from Oklahoma City. Her dream to teach science in an inspired and hands-on way—as opposed to the traditional lecture system with its overemphasis on vocabulary—began to fade as she faced the realities of teaching at a small, isolated school with meager resources. “There was so much I wanted to do—and so little to do it with,” she recalls.

When McCarty arrived, the school allotted no money for science teaching and had almost no supplies for her labs and classes. Although her superintendent managed to scrape together some of what she needed, McCarty grew increasingly frustrated at having to make do, and she began to think that she was failing her students.

Rural science teachers nationwide echo McCarty’s story of frustration. To teach science is a challenge everywhere, but rural teachers confront a trio of special problems that can sap their morale and undermine the quality of education they offer their students, problems that directly affect the one in four children who attend school in rural areas with populations less than 25,000:

- *A scarcity of money.* Although some rural schools boast generous budgets and well-stocked labs, many others, like the one in Duke, must scrimp to acquire basic equipment and supplies. According to the Rural School and Community Trust, 244 of the 250 poorest counties in the nation are rural.
- *Isolation from the world of science.* Rural teachers and students rarely get to meet scientists or see how they work. Enriching activities that urban teachers take for granted—trips to a zoo,



planetarium or lab, as well as classroom visits from scientists—are difficult to arrange.

■ *Isolation from colleagues.* Many rural science teachers have no colleagues nearby, leaving few opportunities for swapping ideas with peers or for commiserating. These teachers often feel they are struggling alone in a sea of troubles.

McCarty almost quit, but she didn’t because she was chosen to participate in a program supported by hhmi at the Oklahoma Medical Research Foundation (OMRF) in Oklahoma City. There, she spent the summer working in Philip Silverman’s molecular biology lab, isolating viruses from cow manure. She says that mundane-sounding experience changed her outlook and teaching style, renewed her confidence and reignited her zeal. She stayed at the school in Duke for



LISA HOKE

another three years, then moved to a nearby high school to continue teaching science.

OKLAHOMA'S RAW MATERIAL

Silverman loves to say that manure is the magic ingredient for the teacher education program he heads. Every summer, Silverman and colleagues invite a select group of four to six science teachers to OMrf for the nine-year-old Foundation Scholar Program, part of Silverman's Oklahoma Science Project, which is one of several programs around the country designed to improve rural science education and tackle the problems of insufficient resources and teacher isolation.

Many of these programs immerse teachers in lab work for a few days or weeks. In designing the Foundation Scholar Program, however, Silverman discarded the format and content of the traditional summer workshop. The last thing most rural teachers need, he says, is to spend time mastering state-of-the-art laboratory equipment and techniques that are impossible to reproduce in their classrooms. Instead, they need to learn simple, inexpensive experiments that students can do, experiments that drive home fundamental concepts such as natural selection, genetic inheritance and gene regulation.

Frustrated by isolation and poor funding while teaching science in rural Oklahoma, Robbie McCarty (above) entered a program run by Philip Silverman (left) and found ways to make science teaching work.

"We went back to some of the classic molecular genetic experiments that are very simple technically, very inexpensive and intellectually very rich," he says. The summer scholars isolate the snippets of DNA called plasmids that confer antibiotic resistance, for instance, or trap bacteria-killing viruses called bacteriophages and measure their rate of multiplication.

These experiments are easy to set up and run, and they use a raw material—animal manure—easily available on the farms and ranches of rural Oklahoma. Thus, teachers can duplicate the studies in their schools, Silverman says, and students can see the relevance of their work in the classroom. Instead of just reading about natural selection,



JOSEPH MILLS

Scientists Recall Country Roots

Some of the world's greatest scientists grew up in the hinterlands. Mathematician Isaac Newton was on his family farm in England when the famed apple fell on his head. Gregor Mendel, the father of genetics, was raised on a farm and orchard in Austria. HHMI also has its share of scientists whose interests in biology or chemistry were germinated in the wide-open spaces of their youth.



"I grew up in a small Midwestern town called Paris, Illinois—not exactly the City of Lights," recalls **Stephen J. Elledge**, an HHMI investigator at Baylor College of Medicine in Houston. "I had two good science teachers in high school, but I was already a scientist at heart long before I knew them." Elledge went through several chemistry sets, eventually blowing up something in his grandmother's kitchen. As a junior in high school, he wasn't sure he wanted to go to college; no one in his family had gone. His science teachers pushed him to go. With a first-place award in a science competition, he went to the University of Illinois on a scholarship.

Stephen J. Elledge studies the cell's response to DNA damage and works on genetic technologies to improve drug development.



Daphne Preuss, an HHMI investigator at the University of Chicago, would have appreciated a female role model as she grew up in the small town of Akron, Colorado. "Most of the people I knew were farmers. The women were wives of farmers. The thing that would have meant the most to me was to see a woman, even on television, who was a scientist." A series of books on adventurers—including Thomas Edison, Booker T. Washington and Marie Curie—helped Preuss see that she could be a scientist too. Her natural curiosity was cultivated by her rustic surroundings. "A

rural environment, where kids have a chance to walk out into the fields and look at the world around them," she says, "can be incredibly nurturing for someone developing as a scientist."

Daphne Preuss uses genetic and biochemical approaches to identify how plants recognize each other, a critical component in understanding interactions within species and between species.



Powtrock Hollow, West Virginia, population 13, was the childhood home of **Gerald R. Crabtree**, an HHMI investigator at Stanford University Medical School. "People on farms are confronted with the realities of biology, physics and chemistry," he says. "We raised chickens, I learned how to plow with a horse and I could fix the hay baler." It was a loving, supportive community that encouraged him to pursue his heart's desires, he recalls. It was also a patient community: One of Crabtree's pleasures in those days was building rockets and entertaining

his friends by setting them off in the nearby hills.

Gerald R. Crabtree studies calcium signaling within the cell and is a member of the National Academy of Sciences.

» Elledge, Preuss and Crabtree share more of their childhood experiences on our Web site: www.hhmi.org/bulletin.

they can observe it in action by using antibiotic-resistant bacteria isolated from samples they collected themselves—often from their own animals. Instead of just reading about viruses, students can grow them on dishes of bacteria and see their effects.

Silverman also likes to let the teachers struggle. Instead of following defined steps leading to a predetermined "discovery," they choose which investigations to pursue and which procedures to follow. This approach approximates how scientists really work and forces teachers to collaborate, getting the peer interaction they crave, Silverman says.

To make sure collaboration continues, the summer scholars leave **omrf** with computers to keep in touch with Silverman and their fellow participants. The foundation provides other help as well—often lending equipment, for example, or shipping supplies for experiments. As a result, "teachers don't feel alone and insecure," says McCarty, who is studying the interactions among the participants for her doctoral dissertation.

Silverman is planning to integrate the program into the undergraduate curriculum for teachers-in-training, and McCarty is helping to lead the way. This fall, she began teaching future science teachers at Southwestern Oklahoma State University at Weatherford, and she plans to adopt the methods of the **OMRF** program in her classes whenever possible.

OUTSIDE WITH EXPERTS

For rural teachers who have few opportunities to work with scientists, a summer program sponsored by the New Mexico Museum of Natural History and Science in Albuquerque, with a grant from **hhmi**, provides experts to lead the teachers and their students through field ecology courses.

Using many of the tools and procedures of professional ecologists, middle- and high-school students and their teachers from around New Mexico dip into streams and rivers to sample water chemistry and collect aquatic invertebrates, according to Tim Aydelott, the museum's ecology education coordinator. They compare a range of locales—from near-pristine mountain springs to heavily developed rivers—to see how human interventions such as agriculture and urbanization affect water quality. With support from a local education group called New Mexico's Math, Engineering and Science Achievement Program, Aydelott and his staff at the museum provide training and equipment for this and other courses, and they dispatch experts on every field trip who demonstrate techniques and help identify specimens. The teachers adapt the program to their own needs and resources, select the field sites and set their own goals, Aydelott says.

Without the museum's help, says Margaret Lewis, her students could never have pursued their current in-depth investigations. Lewis is a science teacher at Memorial Middle School in Las Vegas. (That's the *authentic* Las Vegas, locals like to point out, founded two centuries before the upstart in Nevada.) "The kids are doing things—water-chemistry tests, working with macroinvertebrates—that they usually wouldn't be able to do until college," she says. Lewis and colleague Nancy Jeffrey taught the five-week course last summer, and their students worked at three sites—including the untouched headwaters of the Gallinas River in the mountains above Las Vegas and a spot just below the outflow of the city sewage-treatment plant. In addition to their scientific value, the studies acquaint students with their own environment. "What surprises the kids most is how good the water is that flows through Las Vegas," she says.

Lewis' students have reaped other intellectual benefits. At the culmination of the aquatic ecology program, all the classes meet in Albu-

FROM TOP: PAUL FETTERS; MARK SEGAL; BARBARA RILES



Geoff Johnson

Joan Christen has won accolades and expanded young minds as the lone science teacher in small town Stella, Nebraska.

From Exhausted to Outstanding

Joan Christen teaches life science, earth science, physical science, biology, advanced biology, physiology and anatomy, physics, advanced physics, chemistry, advanced chemistry and environmental science. At the Southeast Consolidated School in tiny Stella, Nebraska, where 234 students attend grades 1 through 12, she is *the* science teacher.

After Christen's first year of teaching, the school almost lost her. Recruiters at the Cooper Nuclear Station, a Nebraska power plant where she had done an internship during college, offered her a job in their environmental department at a hefty pay raise.

"My first year had been exhausting, and the increase in salary was awfully tempting," Christen recalls. But she had already signed up for a summer program at Nebraska Wesleyan University, so before she made a decision, she spent 15 days in Lincoln with 11 other rural science teachers. The science and instructional-technology workshops of the HHMI-supported K-12 Science Teaching Institute were packed with hands-on lessons in biology, chemistry and physics, as well as ways to use computer-based technology and the World Wide Web to teach science.

Fall found Christen back at Southeast Consolidat-

ed, revitalized and eager to make a difference in young people's lives. In the four years since her summer at Nebraska Wesleyan, she has gone on to win \$233,000 in grants to upgrade the school's computers and build an outdoor environmental-education classroom and greenhouse. She has added courses in advanced biology and second-year chemistry to her school's curriculum, completed work for a Master's of Science degree in entomology and convinced her school board to consider hiring a second science teacher. The National Association of Biology Teachers named her Nebraska's outstanding biology teacher of 2001.

Christen says she's glad she stuck with teaching. "I have had some exceptionally talented students, and I feel like I am making a difference in their lives," she says. "The children are our future, and I want and need to do my part." —JENNIFER BOETH DONOVAN

» For more on the Nebraska Wesleyan University K-12 Science Teaching Institute, visit: www.biology.nebrwesleyan.edu/hhmi/index.html

» For more on HHMI's Undergraduate Biological Sciences Education program, visit: www.hhmi.org/grants/undergraduate

querque so the students can present their research results. This meeting is one of the most valuable parts of the program, says Lewis, because it gives these rural kids the opportunity—and the motivation—to prove themselves in the eyes of students from around the state.

VIRTUAL MAGNET SCHOOL

Some rural communities bypass the barriers facing teachers by reaching out directly to students. That's what West Virginia is doing with a statewide *virtual* magnet school created to interest students in health-related professions.

Founded in 1994 with a grant from hhmi, the Health Sciences and Technology Academy (hsta) is directed at minority and financially disadvantaged kids—most from rural schools—who would be the first in their families to attend college, explains program head Ann Chester, assistant vice-president for health sciences at West Virginia University in Morgantown. The year-round program aims to identify students early and inform and motivate their career choices.

The 600 students enrolled in hsta study at their home schools for the most part. They do, however, commit to spending part of each summer, starting after eighth grade, at West Virginia University. During these one- to three-week summer stints, the students immerse themselves in projects that are designed to be practical and lively, says Chester.

In their first summer, the kids compete to design the most efficient digestive tract. "This has a gross component that kids love," she says. In following years, they try to solve a fictional missing persons case from forensic clues and study heart anatomy and function by dissecting cadav-

ers and conducting stress tests. In the final summer, the kids take either a college prep or advanced math class. "They all walk out of here at college level or higher in math before they hit their senior year," says Chester.

To keep the students engaged all year long, she enlisted help from teachers in 21 counties throughout the state. They created after-school "learning clubs" that focus on health-related issues important to their communities, such as water quality or particular diseases. One club in Webster County, for example, used records from the county courthouse to identify heart disease as the leading cause of death in the area. The students then surveyed local people to find out which risk factor was most prevalent. When the predominant one turned out to be lack of exercise, the students laid out a walking trail, indicating on the trail the number of calories people might burn by walking that distance.

Chester says that about 95 percent of the participants in the magnet school attend college; by comparison, the statewide average among high-school graduates is 50 percent. So impressed was the state legislature that it has granted free tuition at any state college or university to students who complete the hsta program.

Although these programs are good first steps, they aren't panaceas. Even the best-designed, most generous programs can't boost tax revenue or conquer geography, and rural teachers will continue to struggle with challenges unknown to their urban and suburban colleagues. Yet, programs such as these can open teachers' eyes to underappreciated resources and help them make the most of their assets. As McCarty puts it: "After my experiences at the OMrf, I began to see ways to make the impossible possible." ■