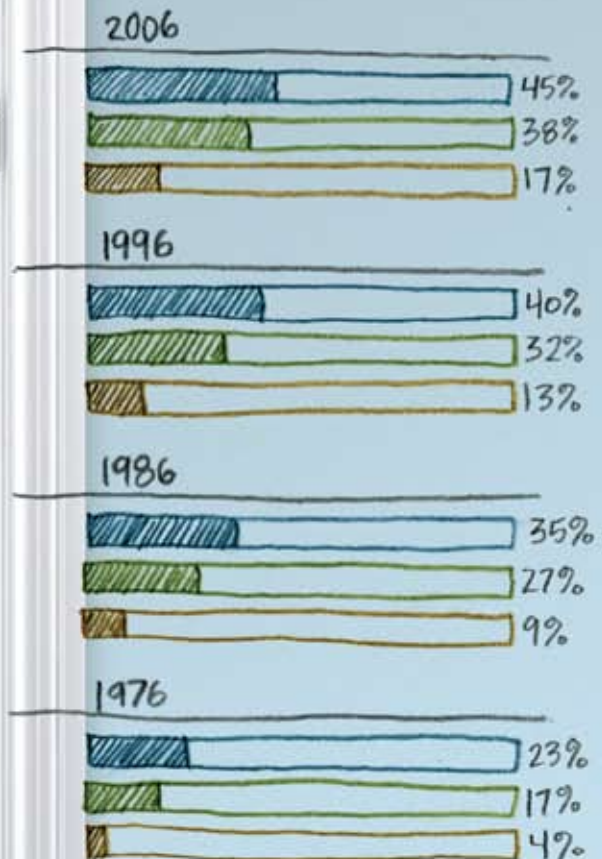
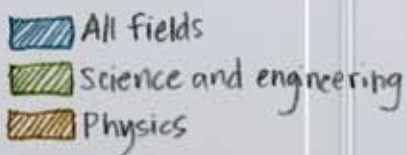




## Percentage of PhDs earned by women



Source: National Science Foundation

# Growing a diverse workforce

**When it comes to training, hiring, and retaining women and members of ethnic minorities, particle physics lags far behind other fields of science. Staffers at three national labs—Fermilab, SLAC, and Brookhaven—are attacking the problem at every level.** *By Rhianna Wisniewski*

When Cherrill Spencer started at SLAC National Accelerator Laboratory as a postdoctoral researcher in 1974, she was one of only three female physicists there.

“I wanted to have more women around me, enough so that we could get our own bathroom,” Spencer says. “I could see no good reason why more women weren’t becoming scientists.”

Today Spencer, who designs magnets that focus and steer beams of particles in accelerators, has many more female colleagues. But she still works hard to encourage the next generation of female scientists.

In 1978, Spencer became involved with the Expanding Your Horizons Network, which works to motivate middle school and high school girls to pursue careers in science, technology, engineering, and math.

The group’s conferences give girls a chance to interact with female scientists and engineers and complete hands-on scientific activities. In a typical year, about 26,000 girls, including 10,000 members of ethnic minority groups, participate in more than 80 conferences in 31 states.

“In just a day-long program you can actually change someone’s mind,” Spencer says. “You can go into a workshop led by a marine biologist and come out wanting to be a marine biologist.”

Many more women and members of minority groups work at Department of Energy laboratories now than 30 years ago. In fact, Asians are represented in far greater numbers than their percentage in the population, mostly because of an influx of immigrant engineers and scientists. But women, blacks, Hispanics, American Indians, and Pacific Islanders are still vastly underrepresented. Statistics compiled from Brookhaven National Laboratory, Fermi National Accelerator Laboratory, and SLAC, for instance, suggest that 22-32 percent of their employees—everyone from cafeteria workers and technicians to administrative staff and scientists—are members of underrepresented minority groups, and 20-28 percent are women. Among lab physicists, the percentages are far smaller.

National laboratories are working with educators to change that—offering training for science teachers, employing college students during the summer, and mentoring students.

They're also working to recruit already-molded minds and to create a workplace culture that entices them to stay.

At Fermilab, a major effort is under way to boost diversity in the workforce by attracting a broad range of job candidates and creating a welcoming environment for people of all backgrounds. The laboratory recently held a series of focus groups to examine the lab's climate, and is adding cultural programs and creating task forces and committees to address diversity issues.

"When you have done your homework, hopefully you'll end up with people who represent different cultures and a good gender mix," says Sandra Charles, equal opportunity specialist at Fermilab. "That requires the entity to take a look at including all people in a respectful workplace environment"

### **Progress steady but slow**

Women and members of underrepresented minorities have gained ground in scientific fields.

From 1966 through 2006, the percentage of PhDs earned by women in all science and engineering fields increased from 8 percent to 38 percent. But while women were earning 34 percent of all chemistry PhDs by 2006, they were awarded only 17 percent of physics PhDs that year, according to the National Science Foundation.

As for minorities, their numbers are still so low that Roman Czujko, director of the statistical research center at the American Institute of Physics, does not like to state them in percentages.

"To tell you the truth, when I produce reports that say that the numbers have grown by 0.4 percent, people read right past it," he says. "That's the kind of thing we're talking about here."

But when people learn that of the 41,446 PhDs granted in physics from 1973-2005, only 303

went to blacks, 504 to Hispanics and 43 to Native Americans, "it has a startle effect," Czujko says.

In addition, large percentages of physics students and researchers in the United States are foreign. American citizens earned 75 percent of physics PhDs in 1973, but only 40 percent in 2006, according to the National Science Foundation.

As opportunities in their home countries increase, an increasing number of foreign scientists are expected to go back, and not enough Americans are being attracted into the workforce to replace them.

With the United States on track to become a majority-minority nation by 2042, it needs to attract more American women and minorities into science to ensure a robust scientific workforce in the future and boost the country's competitiveness, security, and defense, says Ernestine Psalmas, senior program officer for the National Academy of Sciences.

As Bill Valdez, director of the US Department of Energy's Office of Workforce Development for Scientists and Teachers, puts it, "We have a stewardship responsibility to ensure that the next generation of physicists exists out there."

### **Barriers persist**

On paper, there are no reasons why women and minorities shouldn't be rapidly gaining representation in science, engineering, and technical fields. Legal, academic, and governmental actions within the past few decades have addressed open discrimination.

But experts taking a closer look have found cultural, societal, and academic factors that hamper the pursuit of science by these groups.

Ted Hodapp, director of education and diversity at the American Physical Society, believes physics carries a stigma.

"We don't market physics," Hodapp says. "You tell people, 'I am a physicist' and they are put off. You tell them what you're working on and it becomes interesting."

However, the problem goes far beyond a negative reputation.

Math and science, historically, were categorized as male fields. According to *New Formulas for America's Workforce: Girls in Science and Engineering*, a report published by the National Science Foundation in 2003, biases persist in schools, and teachers may offer more encouragement to male students in science and math than to female students. Female students were also encouraged to pursue the less mathematical sciences.

"One thing seems pretty evident: Females are more pervasive in the biological and life sciences," says Ken White, manager of Brookhaven's Office of Educational Programs. "There is a much smaller population of female students in physics,

# JoAnne Hewett

2012

Leads exploration of extra dimensions

1999-2009

Shepherds four grad students to PhDs

1994

Joins SLAC, now full professor

1988-1994

Postdoctoral research at University of Wisconsin, Argonne National Lab

1988

Earns PhD in theoretical physics from Iowa State

1979

Takes first physics course at Iowa State and is hooked

1978

Graduates Pleasant Valley High; excels at math and science but wants to be a musician



# Duane Doles

2015

Creates computer simulation of dark energy in inflationary cosmology model

2012

Howard University  
Earns PhD in  
theoretical astrophysics

2008-2011

Conducts theoretical astrophysics  
research at Fermilab during  
GEM fellowship

2006

University of the District of Columbia  
Earns undergraduate degree in physics,  
with honors

2004

Discovers theoretical physics can be  
a career; applies for Fermilab internship

1990

Graduates F.W. Ballou Senior High  
Excels at math and computer science;  
interested in the big questions



chemistry, engineering, and computer science.”

Although high school students are required to take science classes, they don't always have access to physics. It's offered in only about 45 percent of New York City high schools, according to Angela Kelly, assistant professor and coordinator of the Graduate Program in Science Education at Lehman College, City University of New York.

“At least 75,000 students in New York City attend schools where physics isn't an option,” Kelly says. “In urban areas with a very high under-represented minority population, the numbers are even lower. Only 31 of 82 Bronx high schools offer physics.”

Whether physics is offered depends on many factors, including the school's size and ethnic makeup. When she asked school administrators why they don't offer physics in their schools, Kelly says the response was often, “Our kids can't do it.” They thought physics would be too difficult for most of their students to pass, and were unwilling to spend money to take that risk.

Instructor attitudes also play a role, says Sharon Fries-Britt, an education researcher at the University of Maryland at College Park. She and her students conducted a four-year study on minority high achievers in the classroom as part of a project by the National Society for Black Physicists and National Society for Hispanic Physicists.

In interviews with 100 undergraduate students who were members of underrepresented minorities, Fries-Britt says she saw clear evidence of verbal and non-verbal behaviors discouraging the students from pursuing physics.

Minority students said they felt as if they had to prove themselves in every situation. Their instructors often called their work into question, criticizing sub-par work while speculating that students who turned in excellent work were cheating. This led some students to aim for mediocrity.

“Long-term coping is a challenge for these students,” Fries-Britt says.

### **Stoking a passion for science**

To produce more female and minority scientists, educators and laboratory staff members know they have to start by making science attractive.

“We have to introduce science to children in junior high and high school,” says Shirley Kendall, diversity manager for Brookhaven. “We have to get them at the very beginning and we have to sell science as a cool, integrated part of their future.”

An activity at Fermilab reveals stereotypes elementary school children have about scientists.

Before visiting the lab, students are asked to draw their impressions of what a scientist looks like. Most often, they draw white male scientists in white lab coats. After touring Fermilab and meeting with scientists, students tend to draw both male and female scientists of varying ethnicities

in a variety of hair styles and attire.

Providing role models and mentors is another approach.

Some national lab scientists, like Spencer, reach out to young people through non-profit groups. Others participate in lab-sponsored education and outreach programs, such as lab open houses, science bowl competitions, and field trips.

Nearly 100 high school students come to SLAC each February for the DOE's regional science bowl, an academic competition that tests students' knowledge of mathematics and science.

Brookhaven brings in faculty members from historically black colleges and universities to conduct science at the laboratory.

“These faculty from minority-serving institutions develop strong relationships and collaborations with researchers at Brookhaven,” says White. They bring students with them, and take their science experience and enthusiasm back to the classroom.

Fermilab also offers teachers three consecutive summers of training as part of Academies Creating Teacher Scientists, a DOE-funded program. They do scientific research the first year, learn teaching techniques the second and focus on reaching out to other teachers during the third.

Michael Johnson, a former electronics engineer, switched to teaching in 2003. He entered the program to learn how to teach science at the Robert Emmet Academy in Chicago, one of the lowest-scoring schools on the LSAT in 2006.

“This program is making me look at science from a whole new perspective,” Johnson says. “I'm learning leadership skills and other skills that I can take back to other teachers and other schools. I'd like to teach teachers how to teach science.”

### **Building momentum through mentoring**

Of full-time freshmen at American four-year colleges who said in a 2006 survey that they would probably major in physics, 21 percent were women, according to the Higher Education Research Institute at the University of California, Los Angeles. That's a dramatic increase from 1973, when only nine percent were women.

But while 21 percent of bachelor's degrees and 23 percent of master's degrees in physics went to women in 2006, they earned only 17 percent of the physics PhDs that year, according to the National Science Foundation.

To plug leaks in the educational pipeline for women and minorities, laboratories are trying to engage and mentor college students such as Duane Doles.

Growing up in a predominantly black neighborhood in northwest Washington DC, Doles was always interested in life's big questions, and traveled across town to attend a public high school specializing in math and science. But until he met Fermilab scientist Herman White at

# Brianna Stephens

Future

exciting adventures await!

2010

Freshman, High School  
Takes geology and as many other  
science classes as possible

2008

8th grade physics field trip for  
Beauty+Charm Physics Workshop

2007

Dissects frogs in 7th grade  
science class

2005

Spends summer in Fermilab Science  
Adventures; hands-on experiments  
are her favorites



the National Society for Black Physicists annual meeting in 2004, he never knew that his interests could become a career.

Doles applied for a summer internship at Fermilab that year, and spent the summer after his sophomore year at the laboratory in the Students in Science and Technology program.

"Before the internship, I didn't know that becoming a theorist was a career option," Doles says. Today, he is a third-year graduate student from Howard University working at Fermilab, where he is simulating the design of a new astrophysics project.

"The scientists here were mentors for me at the undergraduate level and continue to be at the graduate level," he says.

For graduate students like Doles, the National Consortium for Graduate Degrees for Minorities in Engineering and Science, known as GEM, offers fellowships to members of underrepresented minorities who are pursuing masters' degrees in science and engineering. The program has paid part of Doles' tuition, enabling him to continue to study and work at Fermilab.

Many of the national laboratories participate in DOE's Science Undergraduate Laboratory Internship Program, which is dedicated to motivating students who may not otherwise pursue careers in the sciences. Another DOE program, Community College Initiatives, encourages students to continue to pursue science majors after transferring to four-year institutions.

In addition, individual labs have their own programs. For instance, SLAC's Youth Opportunity Program provides disadvantaged people ages 18-22 with full-time summer jobs to help offset their education expenses and motivate them to remain in school.

### **Attracting and keeping workers**

Expanding the pool of strong female and minority candidates for jobs in the basic sciences is the primary focus of recruiting and outreach efforts, Kendall says.

"Progress is very slow," she says. "We all have the same goal—to attract top talent from all groups for the purposes of having a diverse workforce and inclusive work environment. Most organizations are in a similar position, which is not there yet."

Unfortunately, when it comes to competing against businesses in private industry, national labs often lose the salary war, says Dianne Engram, Fermilab's diversity officer. Retention can be even more challenging; she and Kendall note that they often see employees who trained at the lab take their skills to private companies.

To prevent this, the lab must offer competitive pay, clear career paths, and a welcoming, inclusive, and accepting culture.

Two committees of the American Physical

Society visited Fermilab in May 2008 to assess the climate for women and minorities in physics and closely related fields and to advise the laboratory leadership on how to improve inclusiveness.

They concluded that Fermilab needs to implement a code of ethics requiring all lab employees and users to treat each other with respect; improve training among leaders at the laboratory; and increase communication and transparency regarding decision-making processes and results.

In response, Fermilab hired an independent facilitator who ran 25 focus groups to examine whether the report's findings stemmed from a systemic pattern of bias within the laboratory.

"The APS report presents some serious allegations and the lab wanted and needed to take it seriously," says Doug Sarno, principal of Perspectives Group, Inc. and facilitator of the focus groups.

Sarno invited a random cross section of lab employees to participate, and spent weeks interviewing laboratory staff and users from all fields.

"What we didn't find was a systemic condition," Sarno says. "The laboratory is diverse well beyond the normal workplace because of the many international cultures working together in every aspect of the lab. Fermilab employees have learned to handle this diversity really well."

At the same time, Sarno says that the APS committees did identify real problems.

"The APS heard some individual stories from graduate students and women," he says. "These absolutely happened, but they didn't happen as a result of Fermilab's current policies and culture and were not condoned."

To further increase diversity at Fermilab, Engram and Charles are leading an effort to create a more comprehensive and more inclusive program.

They're establishing committees to address diversity issues and act as liaisons with the Diversity Office. The pair has also boosted the number of events celebrating the dozens of ethnicities and backgrounds of laboratory employees and users.

More needs to be done, Engram says. She hopes to get a mentoring program started for full-time employees, and wants to increase awareness of her office's diversity initiatives.

Although the climb is steep, Engram isn't about to back down. She, along with other diversity officers throughout the national lab system, is working to create a future that is open, inviting and inclusive.

They acknowledge it won't be easy or quick. But they're determined to get there.