

MAKING A DIFFERENCE: ETHNIC DIVERSITY IN PHYSICS

For years now, it seems, the physics community has talked about the need to increase the number of African Americans, Hispanics and Native Americans within its ranks, and both money and effort have been spent to achieve that goal. As measured by standardized test scores, there is evidence that we have had some success in improving the overall quality of science education for minorities. The number of minority students who enter college intending to major in science has also increased.¹ However, there has been no significant corresponding rise in the number of physics BS or PhD degrees earned by minorities.

Given the current problems in the physics job market, it would be easy to question our emphasis on recruiting and retaining underrepresented groups in physics. And given the persistently low numbers of minority graduates, one could also question the efficacy of affirmative-action programs. However, continued attention to this issue sends the strong message that we believe greater diversity in physics is both good for the profession and important to our nation's interests. And morally it is the right thing to do. From a purely practical standpoint, affirmative action will not alter the job market for graduates: Even if the number of minorities graduating in physics were to double, the total number of degrees awarded would not change significantly.

My personal observation is that minorities go into physics for the same reasons that others go into the field—they love science, they are good at doing science, and they have role models who demonstrate the joy of doing good science. If we assume that there is a pool of minorities who meet such criteria, and if we also accept that students tend to go into those fields in which they receive some encouragement, then the paucity of minorities in physics is due in part to our inability to find them and encourage them to enter the profession.

Persistently low numbers

There are few more dramatic indicators of this country's failure to provide all of its citizens with equality of opportunity than the percentage of physics PhDs awarded to African Americans: For the past several years it has remained at barely 1%, although college-age blacks constitute about 14% of the US population. This disparity is even larger than the 10-to-1 ratio of men to women

If we are to overcome the major obstacles to science education for all, it will require the dedicated efforts of the entire science community.

James H. Stith

among new physics PhDs.

Data from the American Institute of Physics for 1993–94 indicate that at the undergraduate level, slightly less than 7% of the physics graduates in this country were black, Hispanic or Native American (283 of 4283 BS recipients).² At the doctorate level, these numbers

dropped to slightly more than 1% (20 of 1481 PhDs). One encouraging finding is that the number of black women receiving BS degrees in physics doubled between 1985 and 1993 and now appears to be holding steady. But this was accompanied by a 22% drop in the number of black men earning BS degrees. At the PhD level, 11 degrees were earned by US blacks in 1993–94. Hispanics accounted for 103 of the BS degrees and 9 of the PhDs awarded in 1993–94. The corresponding numbers for Native Americans were unavailable, but in 1992–93, they were 8 and 3, respectively.

As shown in the tables on page 40, from 1973 to 1993, 18 US physics departments graduated nearly half of all Hispanics who received PhDs (112 of 250). Similarly, 12 departments accounted for half of the blacks who earned physics PhDs (82 of 152). Of the 172 PhD-granting departments, 87 did not produce a single Hispanic PhD physicist and 110 did not produce a single black PhD physicist during this entire 21-year period (see figure 1).³

Not surprisingly, the underrepresentation of minorities can also be found among science faculty at US colleges and universities. In 1992, blacks and Hispanics accounted for 2% and 1%, respectively, of all faculty in the natural sciences. In addition, minority faculty are less likely to have tenure; in 1989, only 27% of black faculty members were full professors, compared to 42% of white faculty.⁴ This underrepresentation is also prevalent in the high schools, where the percentage of physics teachers who are minorities is somewhat less than 4%.⁵

Discussions about the abysmal minority representation among faculty and graduates often focus on the poor preparation of minority students during elementary and secondary school. Yet there is increasing evidence that the underlying reasons are deeper and more systemic. Consider data from the US Department of Education's *High School and Beyond* study.⁶ Among students having above-average skills and college aspirations, there was virtually no difference in the proportions of Asians, Hispanics, blacks and whites who took physics, chemistry and calculus in high school (see figure 2). But once this group left high school, significant disparities appeared. Among those who went directly on to a four-year college, 65% of

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Departments accounting for half of all physics PhDs earned by black US citizens from 1973 to 1993

	Physics PhDs to blacks
Stanford University	20
Howard University	14
MIT	14
University of California, Berkeley	6
Kent State University	5
University of California, Los Angeles	5
American University	3
Brown University	3
Catholic University of America	3
City University of New York	3
New York University	3
Princeton University	3
Total number of physics PhDs earned by US blacks from these 12 departments	82
Total number of physics PhDs earned by US blacks from all departments	152

Source: NSF

Departments accounting for nearly half of all physics PhDs earned by Hispanic US citizens from 1973 to 1993

	Physics PhDs to Hispanics
MIT	9
Penn State University	8
University of California, Los Angeles	8
University of Texas at Austin	8
Texas A&M University	7
University of Illinois at Urbana-Champaign	7
University of Maryland at College Park	7
Stanford University	6
University of California, Berkeley	6
University of Massachusetts at Amherst	6
Cornell University	5
Florida State University	5
Georgia Institute of Technology	5
Harvard University	5
State University of New York at Stony Brook	5
University of Arizona	5
University of Florida	5
University of Pennsylvania	5
Total number of physics PhDs earned by US Hispanics from these 18 departments	112
Total number of physics PhDs earned by US Hispanics from all departments	250

Source: NSF

the whites and 62% of the Asians earned a bachelor's degree, compared to 49% of the Hispanics and 37% of blacks (see figure 3). For the remainder of the group—who either attended two-year college or vocational school or else did not immediately continue their educations—32% of the whites eventually got a bachelor's degree, versus 20% of the Hispanics and 17% of the blacks.

Why do such differences occur, even among the best prepared and the most motivated? An assumption long held by many educators is that college students who major in science, mathematics or engineering become interested in those fields early in life. But this belief may be incorrect. In a recent NSF study, nearly 60% of those who majored in science, math or engineering had no plans to do so when they were high school sophomores.⁷ What's more, the number of students who chose those majors after their sophomore year of college was nearly the same as the number who had made that decision as high school sophomores. These findings suggest that if we are to be successful in attracting and retaining minority students, we must find ways to allow for the smooth transition from one major to another and rethink our assumptions about why students enter math and science.

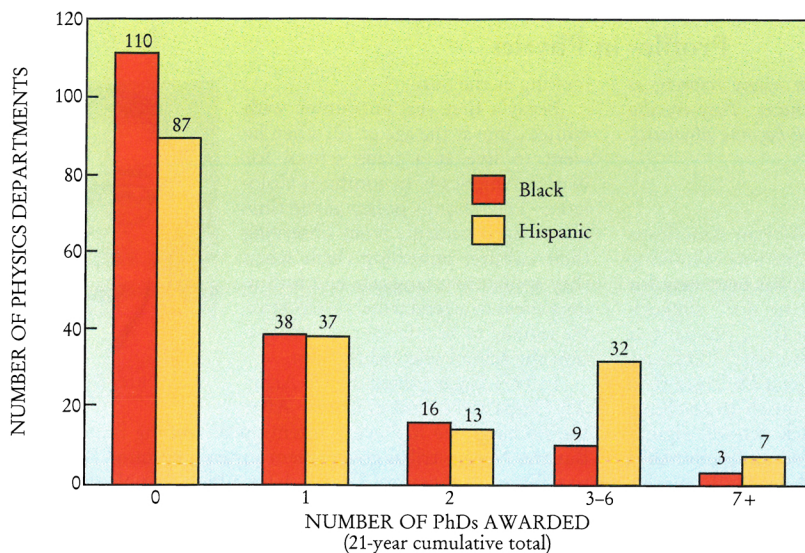
Creating greater diversity

There is no shortage of ideas about how to improve the success rate of minority students in the sciences. Elementary and secondary schools have been encouraged to reallocate their resources for increased mentoring and teacher development. Secondary schools have been urged to form partnerships with nearby universities, national laboratories and local industry. Neighboring schools have arranged to share equipment and other limited resources. While the above approaches are often looked upon as long-term solutions, let's consider a few that are more short-term.

Many colleges and universities make valiant efforts to recruit a student body that is ethnically diverse. Yet when one compares the demographics of the incoming class with that of the graduating one, there are glaring differences. Successful recruiting, too often, does not translate into successful retention. A recent NSF report cited "a variety of . . . social and academic obstacles" confronting minority students in science and engineering, including "financial difficulties, poor precollege preparation, low expectations from instructors, negative peer pressure, difficulty bridging the gap between their cultural identity and the world of science, and poor access to information on postsecondary educational opportunities."⁸

What have successful departments and institutions done to lower attrition rates among minority students? Based on my own observations and extensive discussions with colleagues and students, in almost every institution that has increased the number of minority students, there is someone—usually the department chair, a senior faculty member or a dean—who makes it a top priority. This person, with the support of the institution, has personal contact with the students both before and after they are admitted. He or she ensures that the best students are invited to visit the campus. He or she provides support to both faculty and students, serving as the linchpin around which a successful mentoring program is built.

Of course, every student, not just the minority student, needs an adviser who does more than simply check that the student is fulfilling graduation requirements. Faculty members should be willing to share their experiences and excitement about physics. They should also be sensitive to students' emotional and social needs, recognizing that in many cases (and especially with minorities), they are dealing with first-generation college students.



OVER A 21-YEAR PERIOD beginning in 1973, 87 of the 172 physics departments that grant PhDs produced no Hispanic PhD physicists and 110 produced no black PhD physicists. At the other end of the spectrum, some schools have made concerted efforts to graduate more minorities, as shown in the tables on page 40. (Adapted from ref. 3.) FIGURE 1

Many young people arrive at college without really knowing how to study or how to manage their time. A good adviser addresses these matters.

Educators agree that the lack of role models and mentors contributes to the high attrition rate among minorities in the sciences. In departments where there are no minority professors, inviting minority colloquium speakers will help provide those role models and also create an opportunity for long-distance mentoring relationships. All students, not just students of color, benefit from such diversity.

Fighting isolation and stereotypes

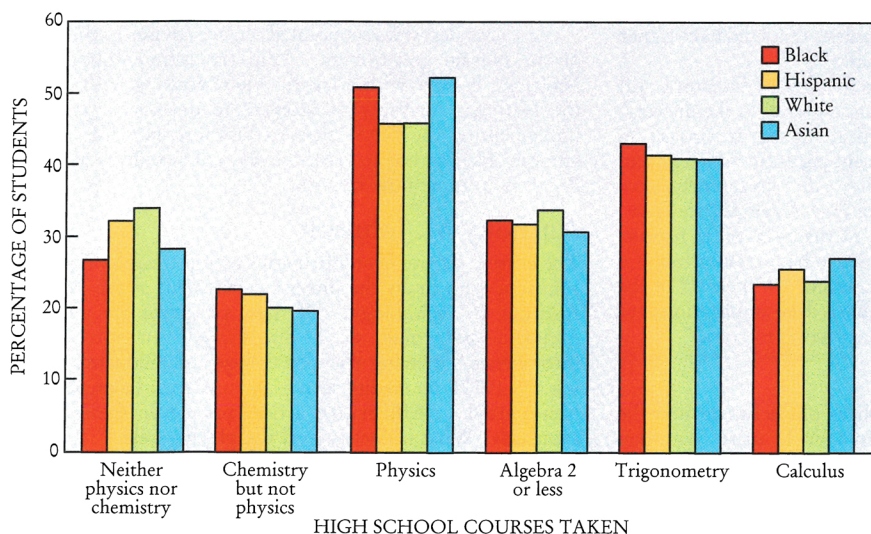
It is important to address head-on the feelings of alienation and isolation that minority students often feel. They may wonder, Do I really belong here? if they constantly receive the signal that their presence is due solely to meeting an affirmative-action quota. Strong and successful departments build a close-knit family, in which all students feel welcome.

Ensuring that there is a "critical mass" of minority students is an important first step in reducing isolation. While it is difficult to say how many students constitute

a critical mass, the number is surely greater than the one or two to be found in most institutions at present. In the absence of a critical mass within the department, many minority students benefit from joining organizations such as Minority Students in Physical and Mathematical Sciences, the National Society of Black Physicists, the Society for the Advancement of Chicanos and Native Americans in Science and the National Technical Association (see box on page 45). Departments can also obtain helpful information on minority issues from the American Physical Society's Committee on Minorities in Physics, the National Action Council for Minorities in Engineering (NACME) and the National Consortium for Graduate Degrees for Minorities in Engineering and Science (known as GEM).

To foster interaction within the department, students should be urged to form study groups; many students have told me that peer mentoring was just as important to them as faculty mentoring. The department should also set up computer and laboratory resource rooms where students can get help.

Additionally, sustained efforts must be made to combat stereotyping and promote ethnic sensitivity. The conscious or unconscious bias of faculty is often mentioned

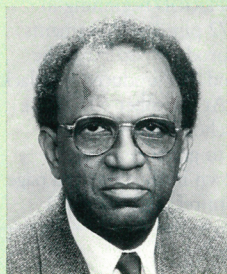


REGARDLESS OF RACE, students who had above-average skills and college aspirations took high school physics, chemistry and calculus in virtually the same proportions. Once this group left high school, however, significant disparities appeared. (Adapted from ref. 6.) FIGURE 2

Profiles in Physics

The physicists portrayed here are exceptional in many respects: as researchers and educators, as role models and mentors. They are also among the small group of minorities who have become physicists. What made a difference for them?

Joseph A. Johnson III



JOSEPH A. JOHNSON III

Why don't more African Americans go into physics? "One way of looking at it is to ask, What has been easy for a black physicist to do?" suggests Joseph A. Johnson III, a physicist at Florida A&M University. "The easy thing has been to get a PhD and then immediately bury oneself in teaching, typically in a black school, significantly underpaid and undernourished by the traditional feedback mechanisms that one associates with doing science. It's a very uninspiring picture for a student who is shopping around for something to do with his

or her life." But when students see a black physicist doing exciting work and receiving proper recognition for that work, "it's a compelling scenario."

"This is really an opportunity and a responsibility of the physics community," Johnson says, "to make sure that all of these students who are newcomers to the discipline have a chance to catch a sense of the excitement of what we do."

While still an undergraduate at Fisk University in the late 1950s, Johnson decided he wanted to do physics research. "The one person I knew who was a PhD physicist, James Lawson, projected a real excitement about spending one's life doing physics," he says. "That was really quite rare and special." After graduating from Fisk, Johnson went on to graduate school at Yale University, earning an MS in 1961 and a PhD in 1965. He then spent three years at Bell Telephone Laboratories before starting his academic career, which took him first to Yale and then to Southern University, Rutgers University and City College of New York, and finally to Florida A&M, where he now directs the NASA-FAMU Center for Nonlinear and Nonequilibrium Aeroscience and is a distinguished professor of science and engineering.

Having set his sights on a research career, Johnson says, "I expected things to be harder for me. I was aware that many of the difficulties I had—getting published, getting funding, getting invited to give talks—were peculiarly associated with the fact that I am black. But I worked around it, building alliances that were useful, taking advantage of the opportunities that I did have rather than dwelling on the ones I did not have."

After 30 years in research, the excitement of his work still keeps Johnson going. "Sometimes I catch myself in the mirror," he says, "and I'm almost embarrassed at my age to project so much enthusiasm." He mentions a recent paper, in which he and his group describe evidence for what they call "natural turbulence closure." Using a diagnostic technique they developed for measuring velocity at very fast data rates, in the 5–10 MHz regime, they got results suggesting that turbulence has a resolution at a microscopic, rather than macroscopic, level. "In the cold of the night, I imagine that this work will have deep implications for how people look at turbulence for many years to come."

Fred Begay

Though he grew up not far from where physicists devised the first atomic bomb, Fred Begay lived in a world apart. As a boy on the Navajo Indian Reservation, a 36 000-square-mile expanse in Arizona, Utah and New Mexico, he spoke only Navajo and Ute, the languages of his parents, and he learned to tell time by

looking at the Sun.

Begay's first real encounter with whites came at the age of 10, when he went to live at a trade school for Native Americans in southern Colorado. The school's policy at the time discouraged students from observing their culture, punishing them when they spoke their language and forbidding them to attend tribal ceremonies. He trained to be a farmer, an occupation the school selected for him.

In 1951 Begay joined the US Army Air Corps and served in Korea. After

his discharge, he had every intention of coming home to farm. But the Navajo tribal government instead recruited Begay to go to college. "Of course, I didn't have a high school education, so that was a problem," he recalls. He enrolled in a special program for veterans at the University of New Mexico, going to college during the day and high school at night.

"The tribe wanted me to go into mechanical engineering," Begay says. "But as I proceeded with my studies, I just had a lot of questions about how things worked, where did all those numbers in the textbooks come from. The professors got very annoyed with me." And so he switched to physics, even though that meant losing his Navajo scholarship. Finally his questions found their answers.

"I had a tough time initially, trying to learn all these fields—even English—for the first time." Christopher Leavitt, a physicist at New Mexico, befriended him and offered advice about physics and mathematics. At the time, the university was a center for cosmic-ray research, and Begay fell into that work naturally. He earned his BS in 1961, MS in 1963 and PhD in 1971.

The further he went in physics, the more interesting it got, Begay says. "I started to have fun." Over the years, he's done theoretical and experimental studies in neutron, solar wind, thermonuclear fusion, plasma and elementary particle physics; he is currently using fractal geometry to understand some fundamental properties of plasma, quantum and relativity physics.

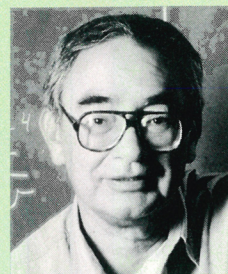
To this day, Begay says, he is the only Navajo to hold a physics doctorate, and he realizes that not every Native American finds the field as welcoming as he did. He acts as a long-distance mentor for many Navajo students throughout the country. "It's a tough road to go on," he observes. "I get these phone calls from students, and they're just ready to quit." In his quiet voice, he tells them to stick with it; later he follows up by contacting their professors, to let them know the students need help.

Last year Begay was appointed science adviser to the president of the Navajo government. "I'm the John Gibbons for the Navajos," he says with a laugh. He's working with officials at the National Academy of Sciences to develop a program for implementing the NAS science education standards in Navajo schools. Having had to learn the ways of two disparate cultures, Begay is at home now in both.

Anthony M. Johnson

The current debate over affirmative action troubles Anthony M. Johnson, who heads the physics department at the New Jersey Institute of Technology. "If these programs are pulled, then minorities and women will be discouraged even more from going into science." Having attended college and graduate school during the 1970s, he credits such programs with having helped get him started. "Affirmative action has never meant lowering standards. What it does is level the playing field."

As he was growing up in Brooklyn, Johnson says, "my family and friends were always supportive, even though I was the only one who pursued a career in science. I don't think that happens



FRED BEGAY

today, particularly among childhood friends—there's a lot of negative peer pressure not to study, not to be smart."

Johnson has fond memories of his high school physics teacher. "Mr. Harnik made physics so interesting to the point where I decided not only did I want to study physics, I wanted to go to the same school he went to." That was the Polytechnic Institute of New York (now Polytechnic University), where Johnson enrolled in 1971. To pay for college, he took out loans and worked part-time in the campus mailroom.

In 1974 AT&T Bell Laboratories began a summer program for minority and women undergraduates, and a professor urged Johnson to apply. "I hadn't even heard of Bell Labs," he says. "But that summer just changed my whole life." He spent ten weeks working with high-speed lasers in David H. Auston's lab. From that experience came his first technical paper, published in the *IEEE Journal of Quantum Electronics*.

Johnson went on to graduate school at City College of New York, receiving his PhD in 1981. He then joined the research staff at the Bell Labs facility in Holmdel, New Jersey.

"When I got to Holmdel, there were a few people who clearly regarded me as an 'affirmative-action hire' and therefore no good. But I knew I had something to offer." He soon began approaching researchers about collaborating on projects and in time built up a well-regarded research program. In 1988 Johnson received the labs' Distinguished Technical Staff Award for Sustained Achievement for his "pioneering contribution in nonlinear optics, ultrafast optoelectronics and ultrashort laser sources." "I cherish the years that I spent at Bell Labs," he says.

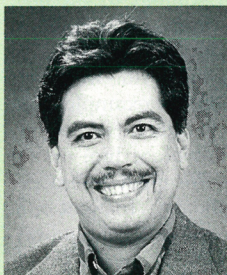
In 1995 Johnson moved to the New Jersey Institute of Technology, where in addition to his myriad administrative duties, he's once again building a lab for ultrafast optics and optoelectronics. This fall, he'll teach his first course, on high-speed nonlinear optics.

Over the years, Johnson has mentored many minority students, and he tells them the same thing: get hands-on experience in the lab, as he had done, join in peer discussions whenever possible and remember that "sometimes you've got to push your way in and show them that you can contribute, that you belong."

Carlos J. Gutierrez

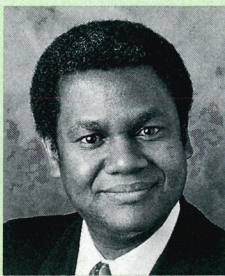
When Carlos Gutierrez was in graduate school at Johns Hopkins University, he marveled at how well-adjusted many of his fellow students seemed. "They had this amazing network of friends and relatives who were professors at universities or scientists working at government labs," Gutierrez says. "A Latino kid from Texas just doesn't have that."

Now an assistant professor of physics at Southwest Texas State University, Gutierrez was born and raised in San Antonio and majored in physics at the University of Dallas, a small liberal arts



CARLOS J. GUTIERREZ

school. Several months before graduating in 1983, he paid a visit to the University of Texas at Austin, where he'd been accepted into the PhD program. "It scared me—it seemed very large and impersonal, and I was told by other students that there was a high attrition rate in physics," Gutierrez recalls. He knew he would need advice on research options and a chance to "make up" for weaknesses in his undergraduate education. "It wasn't obvious that I would get that at UT."



ANTHONY M. JOHNSON

By then it was too late to apply somewhere else, so Gutierrez took a job at Kelly Air Force Base while he pondered his future. He decided he wanted to be an astrophysicist, and a year later he enrolled at Johns Hopkins, where the Space Telescope Science Institute had recently been established.

The culture shock was dramatic. "There was no Latino community in Baltimore at the time," he says. "I hated it so badly that I thought seriously about transferring." But as time went on, he grew to like and even love the city.

He also "discovered" a field he liked even more than astrophysics: experimental solid-state physics. During his third year, he began working in Cal Walker's lab, studying the magnetic properties of artificially structured iron-silver multilayers fabricated by molecular beam epitaxy. In 1989 he met IBM physicist George Castro, who invited him to a speak at a meeting of the Society for the Advancement of Chicanos and Native Americans in Science. "It was tremendous to see a group like that," Gutierrez recalls. He now serves on the SACNAS board of directors.

After receiving his PhD in 1990, Gutierrez became a postdoc in Gary Prinz's group at the Naval Research Laboratory in Washington, DC. There he met and worked with some of the top researchers in his area. Being introduced to that "inner circle" has been extremely important, Gutierrez says. For one, "reviewers tend to be more open-minded if they know you or your adviser." His recent work includes studies of hybrid magnetic-semiconductor devices for microwave and optoelectronics applications.

In 1992 he joined the physics faculty at Southwest Texas, located in San Marcos, halfway between San Antonio and Austin. The move allowed him to be closer to his family and also to mentor minority students. "Most Hispanic parents don't view physics as a career, and they tend to push their children toward professions like medicine, law or engineering," says Gutierrez. To make physics more "marketable," he and colleagues have developed a bachelor's and master's program in "materials physics," which combines courses in physics, materials science and electronics engineering with extensive lab training in thin film materials. The idea is that graduates will be able to move easily into jobs within the semiconductor and microelectronics industry nearby. "This is the kind of program I wish would've existed in Texas when I was a student."

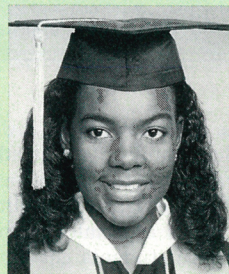
Zelda Gills

The teenagers in Zelda Gills's neighborhood call her Mama Z. "They say I'm in their business too much," she jokes. That doesn't stop her from dispensing much-needed advice about jobs and tutoring them in math and science. For this young physicist is always mindful of how she was helped along by people who cared.

As a child growing up in Baton Rouge, Louisiana, Gills recalls, "I was by no means good at science—I took remedial math in elementary school." But she was curious about how things work, and as her skills improved, her interest in science grew. "My mom was very instrumental in that. She'd come to school and tell the teachers, 'I want my daughter to go as far as she can.'"

At her inner-city high school, Gills says, the resources were limited "but the teachers really cared." The school didn't offer calculus, so Gills's algebra teacher taught her the subject after school.

In 1984, when she entered Southern University and A&M College, a historically black school in Baton Rouge, Gills had thoughts of becoming an engineer or a doctor. Diola Bagayoko, who taught introductory physics, convinced her that physics would prepare her for a variety of careers.



ZELDA GILLS

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He also encouraged Gills to pursue a PhD. She visited several graduate schools, but Georgia Institute of Technology stood out; only there did all of the professors take the time to talk to her and explain their research. "The nailing point was meeting Raj Roy," says Gills. "I really liked the work he was doing [in nonlinear optics], and I liked him as a person." Roy eventually became Gills's adviser.

She had also chosen Georgia Tech to be within driving distance of her mother. That soon proved critical when her mother suffered a heart attack and then underwent surgery to remove a benign brain tumor. On most weekends, Gills was on the road between Atlanta and Baton Rouge. "Needless to say, my first year of graduate school was horrific."

As her mother's health improved, Gills settled down to her studies in earnest. She and five other African American students formed a study group. "We'd talk about everything: physics, relationships, whose house had the most food because we were all broke and couldn't afford dinner." She became active in student and professional groups and helped organize the 1994 National Conference of Black Physics Students.

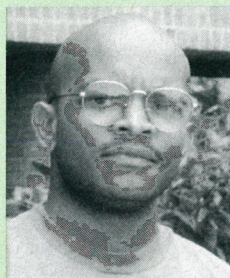
Upon completing her PhD last year, Gills received an offer from Spelman College. "I really wanted that position, to give back to the kind of institution that helped put me where I am today." Then came an offer from AT&T Bell Labs (now Lucent Technologies) in Norcross, Georgia. After carefully weighing the advantages of working in academia versus industry, she chose the latter. Gills now does systems design work on fiber-optic networks for long-distance and local-access communications.

Back in Baton Rouge, Gills's mother recently enrolled in college for the first time. Now it is Gills who offers the encouragement, telling her mother "to go as far as she can."

Donnell T. Walton

Donnell Walton has always had questions. "Most of us start out asking questions," he observes. "But along the way we get varying levels of discouragement, which we handle in different ways. Some people stop asking questions, they stop being critical. I just never stopped." Now a graduate student at the University of Michigan, he remains reflective and self-conscious, about his personal life and his career. "My motivation is understanding things, whether that's physical or social phenomena."

What drew Walton to physics was "the ability to pose



DONNELL T. WALTON

counselor and one of the few black faculty members. "She saw things in me that others didn't see." The summer before his senior year in high school, Floyd got Walton into a science program at MIT. "I wasn't as prepared as many of the kids, and I did horribly—which is to say, I did average," Walton recalls. "The 'failure' intrigued me. I decided that would never happen again."

In 1984 he entered North Carolina State University, where he double-majored in electrical engineering and physics. He became friends with Lewis Johnson, a fellow physics student who is also black. In a 1993 essay, Walton described the difficulties of fitting into the monoculture of physics and how meeting Johnson helped: "When speaking with colleagues about matters outside of physics, I often found myself in the position of 'other.' This isolation was so great that it wasn't until I met someone who culturally reinforced my love of science that I actually considered pursuing physics as a career. It makes all the difference to realize that science and the rest of one's life aren't mutually exclusive." Since then, he's met many other black physicists through the National Conference of Black Physics Students, for which he served as chairman in 1995.

In recent months, Walton has been interviewing for research positions in both academia and industry. He also hopes to continue teaching, something he's enjoyed during graduate school. Most recently, he held a workshop for Detroit public school teachers to show them how to incorporate lasers into their science and math classes. "I find my research extremely rewarding, and that feeling is amplified when I am building bridges as a mentor for younger scholars."

JEAN KUMAGAI

as a reason for the low numbers of minorities in physics. Successful programs address this by establishing training programs for professors and teaching assistants to help them recognize and eliminate such bias in their teaching. This is especially important in the introductory courses, where students get their first taste of the subject.

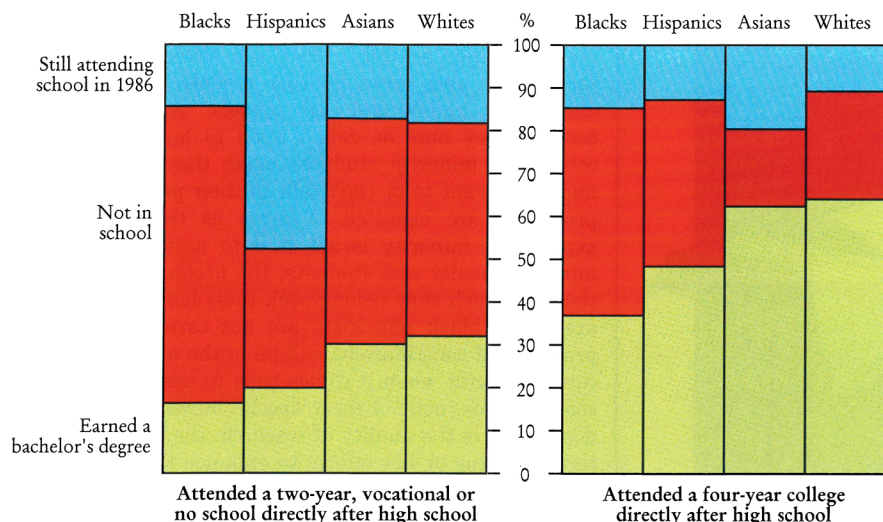
Raising expectations

Minority students often complain that they are expected to fail. A number of dean's list students have described to me how on the first day of class, well-meaning instructors have taken them aside and told them, "If you start having difficulty in this class, make sure you stop by and see me." Knowing nothing about these students, the instructors simply assumed they would need help. Such perceptions place undue pressure on minorities, not only to be just as good as majority students but to be better. Successful departments manage to create an atmosphere in which the expectation of both faculty and students is that all students can and will succeed. The student who makes a C in a course is not doing "all right" if he or she is capable of making an A or a B. I firmly believe that

if we demand excellence from our students, we will get excellence. If, on the other hand, students sense that we believe they are below average, then that is what they will give us in return.

This also means that departments must be realistic when recruiting students at both the graduate and undergraduate level. A careful and realistic assessment must be made of each candidate's skills and background to ensure these are adequate for the student to succeed. By accepting a student, the department is making a statement that it believes he or she has the potential to succeed and also a moral commitment to provide whatever assistance is required. A determination, for example, that a graduate student needs to take an advanced undergraduate course to catch up should not place him or her in danger of losing financial support. We must be sincere in our offers to assist those having difficulty. Institutional and departmental obligations do not end with the admitting process.

Two-way communication between the students and the administration is important. Departmental representatives could meet on a regular basis with students to



AFTER GRADUATING FROM HIGH SCHOOL in 1980, students who had demonstrated above-average skills and wanted to go to college took different routes. Among those who attended a four-year college immediately after high school, 37% of blacks and 49% of Hispanics earned a bachelor's degree by 1986, compared to over 60% of Asians and whites. (Adapted from ref. 6.) **FIGURE 3**

evaluate their progress and, if necessary, explore ways to improve the climate. Important information and materials should be made available to all students.

Financial aid and career advice

A problem that confronts most students is the lack of financial aid. One disturbing recent trend has been for financial aid packages to rely on loans rather than scholarships or grants. As George Campbell, president of NACME, has pointed out, "Universities are shifting their scholarship resources toward the more affluent students, who will increase the institutions' net revenue." Because loans often require students to start paying interest immediately instead of after graduation, this places lower-income students (and most minorities fall into this category) at an even greater disadvantage. Successful programs help students through the paperwork maze of financial aid and also try to shift the balance away from loans and back in the direction of grants and scholarships.

A major leak in the physics education pipeline occurs between undergraduate and graduate school, in large part because students receive little advice about graduate school opportunities. Departments should consider holding seminars for all juniors to highlight graduate school

options, what one needs to apply (letters of recommendation, GRE scores and so on) and the characteristics of a typical graduate program. Pamphlets from a variety of graduate schools should be readily available for students to review. Because many undergraduates have little or no idea what physicists actually do, the department should provide information on career options and the educational requirements for entry into those fields. For example, how does physics provide the foundation for and transition into fields such as medicine, law and engineering? For those in graduate school, what can one do other than becoming a research physicist at a large university?

A national issue

In the discussion above, I have tried to highlight the common threads that run through many successful programs. But each institution is unique. Strategies that work at one may need to be modified to work at another.

Several years ago, during a discussion about what could be done to eliminate racial problems, a colleague said to me, "One of the things that physicists can be proud of is that when we look at the work of a physicist, it is judged on the quality of the work, and not on race."

My response was, "Yes, that may be the case, but

Organizations Concerned with Minorities in Science and Engineering

▷ American Indian Science and Engineering Society, 1630 30th Street, Suite 301, Boulder, CO 80301; phone 303-939-0023, e-mail aiseshq@spot.colorado.edu.

▷ American Physical Society's Committee on Minorities, One Physics Ellipse, College Park, MD 20740-3844; phone 301-209-3232, e-mail modeste@aps.org. The committee provides scholarships to minority physics majors, conducts departmental site visits to assess the climate for minorities and maintains a colloquium speakers list of minority physicists.

▷ Minority Students in Physical and Mathematical Sciences, Suite 508, 1429 G Street NW, Washington, DC 20005; phone 202-484-2207. This group sponsors the annual National Conference of Black Physics Students.

▷ National Action Council for Minorities in Engineering, 3 West 35th Street, New York, NY 10001-2281; phone 212-279-2626.

▷ National Consortium for Graduate Degrees for Minorities in Engineering and Science, P.O. Box 537, Notre Dame, IN

46556; phone 219-287-1097. The consortium is known as GEM.

▷ National Society of Black Physicists, c/o North Carolina A&T State University, 1601 East Market Street, 101 Marteen Hall, Greensboro, NC 27411; phone 910-334-7647, fax 910-334-7283.

▷ Society for the Advancement of Chicanos and Native Americans in Science, University of California, 1156 High Street, Santa Cruz, CA 95064; phone 408-459-4272, fax 408-459-3156, e-mail sacnas@cats.ucsc.edu

▷ National Technical Association, P.O. Box 7045, Washington, DC 20032-7045; phone 202-829-6100.

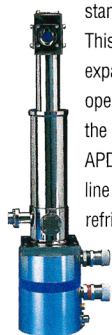
▷ Society of Mexican-American Engineers and Scientists, 204 Zachry Engineering Center, Texas A&M University, College Station, TX 77843.

▷ Society of Hispanic Professional Engineers, 5400 E. Olympic Boulevard, Suite 306, Los Angeles, CA 90022; phone 213-725-3970, fax 213-725-0316, e-mail shpenatl@aol.com.

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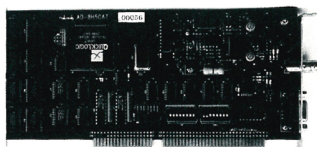
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black physicists are expected to carry some additional responsibilities as well. They are asked to go into the community and serve as role models for students in elementary, middle and high schools. At majority institutions, they may be called upon to help mentor their colleagues' minority students when they have difficulty and don't want to or can't talk to their professors. Black professors are expected to serve as their institution's experts on minority issues and to assist in recruiting minority faculty and students; the professional organizations to which they belong seek their help in these same areas. If black physicists are not careful, all of their professional contributions will be in the arena of minority concerns. But when it comes time to assess the person's contributions, none of these special burdens count. What does count is the quality of research, the person's productivity and his or her efforts to enhance the reputation of the department or institution."

If I were having that conversation today, the only thing I would change would be to replace "black" with "minority." The challenge of recruiting and retaining more minority physicists into the profession is one that should not be relegated to minority physicists. For this is not a minority issue but rather an American one. Unfortunately, far too many of us still believe that learning and achievement come solely from a person's innate ability, that poor performance by certain groups is somehow inevitable. We must move beyond such narrow-minded thinking. In the classroom, we should set reasonable standards and insist that all students meet them. If students are made aware of our expectations, and are given the needed support, they can and will succeed. All of us must become better teachers and motivators of our students. Beyond that, each of us must recognize and respect the cultural differences that exist among our students, and be sensitive to the circumstances of those whose backgrounds differ from our own. The major obstacles to quality science education for all can only be overcome through the dedicated efforts of the entire scientific community. The good news is that the problem is solvable.

Many of the ideas presented here were put forward at the Recruitment and Retention of Minorities in Physics Conference held in Chevy Chase, Maryland, in November 1993. The conference was sponsored by the American Association of Physics Teachers, the American Physical Society, the American Institute of Physics and the National Society of Black Physicists, with additional funding from NSF.

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