Building DIVERSITY in the Scientific Workforce

A Report from the National Science Foundation Minority Postdoctoral Research Fellows and Mentors Annual Meeting

September 11-13, 1996
Arlington, Virginia

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Preface

"Building Diversity in the Scientific Workforce" was the title of a September 1996 meeting of National Science Foundation (NSF) Fellows and their sponsoring scientists. This report was written by several of the meeting's participants, and a draft was circulated to all participants. It documents individual experiences, opinions, and recommendations, not an official NSF position. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the individual participants and not those of the National Science Foundation.

Since 1990, NSF has awarded approximately 12 Minority Postdoctoral Research fellowships each year in the biological, social, economic, and behavioral sciences. Each year Fellows and their mentors are invited to a workshop at NSF to present research findings, share information, and learn about funding for science. For the 1996 annual meeting, all former and current Fellows, their mentors, and minority Fellows from other NSF programs, e.g., NATO, International Fellows, Chemistry, and Math Sciences, were included to document the experiences of NSF Fellows across all areas of science.

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Acknowledgments

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Introduction

The composition of the United States population in the 21st century will be vastly different from that of the 20th century. Fertility and mortality rates, immigration patterns, and age distributions within subgroups of the population are contributing to an increasingly diverse national population. The U.S. Census Bureau projects that the non-Hispanic white population will decrease from 75.7 percent to 52.5 percent of the population between the years 1990 and 2050. During the same time period, the black, Hispanic origin, Asian and Pacific Islander, and American Indian/Eskimo/Aleut populations will grow (see Figure 1). By the year 2050, the black population will double its present size and the Hispanic-origin population will quadruple its size.[1]

Despite these shifts in the population, certain minority groups remain underrepresented in scientific occupations in this country. In 1993, blacks, Hispanics, and American Indians together comprised 23 percent of the U.S. population but only 6 percent of the science and engineering labor force. In contrast, Asians comprised 3 percent of the population but 9 percent of the science and engineering labor force. The proportion of underrepresented minorities at the doctoral level is much smaller, even when compared to underrepresented minorities at the bachelor's degree or master's degree levels. In 1993, blacks and Hispanics each accounted for only 2 percent of the doctoral scientists and engineers in this country; American Indians accounted for less than one half of 1 percent. In addition, minority faculty members at universities are not comparable to whites in terms academic rank and tenure.[2]

Educational attainment levels continue to rise for the black and Hispanic populations. For example, in 1940 the percentages of blacks and whites 25 years and older who had completed high school were 7.7 percent and 26.1 percent respectively. By 1993, 70.4 percent of blacks 25 years and older had completed high school, compared with 81.5 percent of whites.[3] However, there has been less success in closing the gaps among population groups in terms of attaining a college degree—a prerequisite for almost any science career. Between 1940 and 1993, the proportion of black college graduates ages 25 and older increased; however, it is only about one-half of the proportion of white college graduates (12.2 percent compared with 22.6 percent in 1993). Also in 1993, 42 percent of white high school graduates ages 18 to 24 were enrolled in college, compared with 33 percent of black high school

Minorities, particularly underrepresented minorities, provide a rich, though largely untapped resource for building the nation's scientific workforce, particularly as minority populations grow as a proportion of the U.S. population.

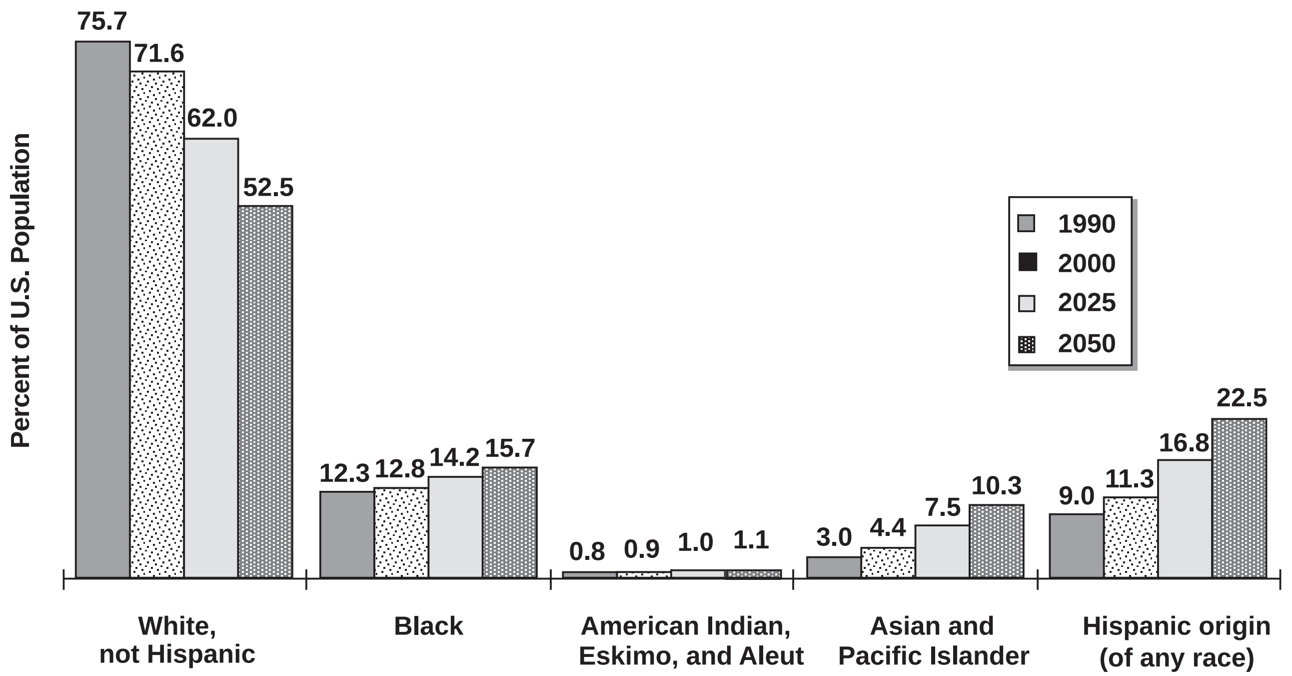
[1] Day, J. C. National population projections. *Population Profile of the United States: 1995.* Washington, D.C.: U.S. Bureau of the Census, 1995 (CPS Report No. P23-189).

[2] *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1996.* Arlington, Virginia: National Science Foundation, 1996 (Report No. NSF 96-311).

[3] Adams, A. Educational attainment. *Population Profile of the United States: 1995.* Washington, D.C.: U.S. Bureau of the Census, 1995 (CPS Report No. P23-189).

FIGURE 1

Projected U.S. Population by Race and Hispanic Origin



Source: Day, J. C. National population projections. *Population Profile of the United States: 1995.* Washington, D.C.: U.S. Bureau of the Census, 1995 (CPS Report No. P23-189).

graduates and 36 percent of Hispanic high school graduates.[4]

Minorities, particularly underrepresented minorities, provide a rich, though largely untapped resource for building the nation's scientific workforce, particularly as minority populations grow as a proportion of the U.S. population. Development of a solid foundation of talented, highly skilled scientists of diverse backgrounds in turn will enable the United States to remain competitive in the global economy.

This report addresses some of the issues surrounding the education and retention of a more diverse scientific workforce. The key issues and recommendations presented here were identified at the National Science Foundation Minority Postdoctoral Research Fellows and Mentors Annual Meeting, held in Arlington, Virginia, in September 1996. This report presents the views of the participants at the Annual Meeting, and is not an official report of the National Science Foundation.

[4] Bruno, R. R. School enrollment. *Population Profile of the United States: 1995.* Washington, D.C.: U.S. Bureau of the Census, 1995 (CPS Report No. P23-189).

Building Diversity in the Scientific Workforce: Recommendations of Postdoctoral Fellows

In September 1996, the National Science Foundation (NSF) brought together a distinguished group of minority scientists and their sponsoring scientists/mentors at the NSF Minority Postdoctoral Research Fellows and Mentors Annual Meeting in Arlington, Virginia. The fellows, who work at academic institutions and research organizations across the nation, represented a range of scientific fields from molecular biology to psychology to geochemistry. At the meeting, the fellows presented five-minute "chalk talks," listened to presentations about the education and career development of minority scientists, and met in small breakout groups to discuss their own experiences and influences in pursuing science careers.

Each breakout group prepared a brief oral report addressing such questions as: What influences led to your interest in science? To what extent has mentoring been important to your continued interest in science? How well has your graduate training prepared you for the current job market or your planned career? And, what difference did the receipt of an NSF postdoctoral fellowship make in your plans and/or success?

In November 1996, a subgroup of six postdoctoral fellows who had attended the Annual Meeting met to summarize issues surrounding the education and career development of minority scientists, based on discussion at the September meeting. The fellows addressed such global and societal issues as the growing gap between the rich and poor, the corrosion of the middle class, racial polarization, the need to build students' and the public's competence in science and math, the changing employment market for scientists, and the impact of affirmative action programs. They also related their own experiences, identified key concepts, and made recommendations for developing and retaining underrepresented minorities in scientific careers.

Overview of Observations and Experiences

The following information summarizes observations, key concepts, and recommendations outlined by the NSF minority postdoctoral fellows, and represents the impressions of the fellows.

Exposure to science and "hands-on" experiences during the early years of life have a tremendous impact on the development of an interest in science and the decision to become a scientist. Reflecting on what led them to pursue scientific careers, minority scientists cite a host of influences that include interaction with adult relatives or friends who were scientists, participation in science fairs, experiences in the natural environment, watching television shows about science, and encouragement received from teachers. Any of these factors may inspire a young person's curiosity and appreciation for science, but perhaps none is more powerful than the influence of teachers and schools. Just one teacher's enthusiasm for science can be critical in a young person's decision to pursue a science career.

A student's perception of science can be positive or negative depending on individual teachers and on the availability and range of resources offered by a school. Minority students face challenges that are either amplified or different from those of their non-minority counterparts.[5] For

[5] The term "minority," as used in this report, refers to three groups of "underrepresented minorities" (Blacks, Hispanics, and American Indians), whose representation in science is less than their representation in the U.S. population.

example, schools in urban or rural minority communities often have fewer or more antiquated resources compared to schools in suburban communities. Blacks attending primarily white or integrated schools sometimes are steered to play on sports teams rather than urged to concentrate on science or math. Guidance counselors and teachers make assumptions about the "best" career directions for minority students, and may unknowingly provide negative reinforcement to those who aspire to higher learning in the sciences. Often a professional school education (law, medicine, or dentistry) is the "track" recommended for bright minority students. In addition, minority students frequently lack exposure to scientists of their own racial or ethnic backgrounds who can serve as role models.

Exposure to science and "hands-on" experiences during the early years of life have a tremendous impact on the development of an interest in science and the decision to become a scientist.

After high school, challenges persist for minority students who decide to pursue science careers and to move through the academic "pipeline." In undergraduate and graduate school, minority students may find that they lack some of the skills needed to compete with their non-minority counterparts. They may be less connected to other students and faculty and, as a consequence, may miss information or opportunities that could help them advance in their training or career plans. Minority students whose parents or friends did not attend college also may not get timely advice needed to maximize their college experience, and thus may be less prepared for graduate school. In addition, minority students may have family obligations or face financial obstacles that prevent them from continuing their training as scientists, although special funding targeted for minority students is now available.

Following graduate school, supportive programs such as the National Science Foundation's (NSF) Minority Postdoctoral Research Fellowship Program help to level the "playing field," enabling minorities to compete more equally with their non-minority counterparts. During this phase of training, postgraduate minority scientists, like their non-minority counterparts, benefit from committed mentors and expanding professional networks that can lead to successful employment in their selected fields.

During the 1996 NSF Minority Postdoctoral Research Fellows and Mentors Annual Meeting, the following key concepts and recommendations emerged regarding the entry and retention of minorities in science careers. Many of these concepts apply to both minority and non-minority persons. However, by improving science education and equalizing opportunities for minority students, all students will benefit.

Key Concepts and Recommendations

Preschool through High School

Teachers must remain current in their fields and in science overall. Those teaching science at the kindergarten through high school level must be provided opportunities and incentives for ongoing professional development. NSF should increase funding for workshops, symposia, and other continuing education programs, such as opportunities to work in research laboratories during the summer months, to help teachers remain current and aware of scientific progress and developments. Mechanisms are needed to assess teachers' knowledge of current science. Recommendations for professional development and retraining should be viewed by teachers as constructive and positive, rather than critical and punitive.

New technologies should be used to increase teachers' and students' access to current scientific information. The vast information resources available through the Internet and other electronic technologies should be used to provide curriculum ideas and to support student projects. Ideally, all school systems would make such resources available to all teachers, and all schools, regardless of their locations or the populations they serve, should have equal access to these resources. At a minimum, teachers and schools that do not have on-line access should be provided current materials in printed or other formats. NSF could work with organizations such as the National Science Teachers Association to develop and disseminate both on-line and printed materials. A teacher-liaison at NSF should coordinate these efforts and serve as a resource.

Teachers must make subject matter relevant to students' lives. Beginning in the preschool years, teachers must instill in students the importance and practical application of science in daily life. Rather than relying solely on textbooks and memorization, hands-on projects, science fairs, and field trips must be incorporated into teaching to demonstrate science's relevance and to promote continued interest in science. Teachers with firsthand knowledge of the scientific work world are better prepared to make science relevant to students. Therefore, continuing education programs at universities or in industry must be offered to keep teachers current in the subject matter they are teaching. In addition, working scientists should be invited to talk with students about science and how it is relevant to their lives.

Teachers and guidance counselors must be made aware of cultural differences. As part of their continuing education, teachers and guidance counselors must receive multicultural awareness training, and must be enlightened about the many factors that impact the academic success of minority students. Such training will help to reduce bias about which students can excel in science, and therefore will minimize preconceived ideas about which students should have an interest in science or pursue science careers.

"When I was a sophomore in college I liked biology, but I was all set to declare a philosophy major. A young African-American biology professor, however, took me under his wing and provided me with my first research experience. He became my friend as well as my mentor, and within a year I had switched to biology. He also encouraged me to consider graduate rather than medical school. I can safely say that I would never have started a career in science without his guidance."

—Michael Romero, PhD

A Proposal to Increase Entry and Retention of Minorities in Academic Science Programs

Minority students face special challenges when pursuing science careers, according to minority postdoctoral fellows funded by the National Science Foundation (NSF). For example, minority students entering college often come from schools in rural or urban communities that offer fewer education resources than those available in middle-class suburban areas; thus, minority students must work harder to "catch up" and achieve the same level of academic success as non-minority students. Many minority students also do not have the benefit of parents who attended college or graduate school and who understand the academic system. In addition, minority students' personal and academic circles often are limited, providing less support and fewer networking opportunities than those of their non-minority counterparts.

Postdoctoral fellows who attended the 1996 NSF Minority Postdoctoral Research Fellows and Mentors Annual Meeting proposed a mentoring system as a strategy to assist minorities in overcoming some of the barriers they face as they progress through the science career "pipeline"—from undergraduate and graduate school to postdoctoral fellowships to employment. The proposed program would be funded and coordinated by NSF with the overall goal of increasing entry and retention of minorities in academic science programs. The system would strengthen networking, improve communication among all levels of academia, provide academic and emotional support, offer assistance in learning the academic "system" to make the most of the university experience, and help develop study skills and career development abilities among minority scientists-in-training.

Through the proposed program, principal investigators receiving NSF research funding would be eligible to receive supplemental awards to pay mentors and to coordinate mentors' activities at the undergraduate, graduate, postdoctoral, and faculty levels. Mentors would be selected through an application and interviewing process. Each mentor would be held accountable and evaluated by his or her protégés. Junior and senior students would serve as mentors for freshmen and sophomores, graduate students for junior and senior undergraduates, postdoctoral fellows for both undergraduate and graduate students, and faculty members for postdoctoral fellows. Mentors would not need to be minorities, but should have attained the goals to which the persons they are mentoring aspire.

As part of the proposed program, symposia would be held for mentors and those they are mentoring. Symposia might address such topics as exploring science career options, improving scientific writing and oral presentation skills, building interviewing skills, preparing effective curriculum vitae, improving technical writing, publishing scientific papers, developing professional networks, marketing oneself, developing a scientific niche, establishing and managing a research lab, and increasing one's effectiveness as a mentor. The mentoring program would also include a component to provide minority undergraduate students' with expanded opportunities for hands-on research experience.

Information and guidelines for mentors and those they are mentoring would be posted on the World Wide Web and would be dynamic, changing with input from those using the Web site. Use of e-mail would also facilitate communication among those who participate in the program.

Teachers must have high expectations of all students. Throughout middle school and high school, all students—regardless of race or ethnicity—must be encouraged to pursue a college education, and then permitted to decide for themselves if that is the direction they wish to take. If all students are considered to be on a college-bound track and offered equal academic preparation, then college entry and higher education will be viewed as an attainable goal for all.

Guidance counselors should guide, not direct students' career decisions. High school guidance counselors must serve as neutral advisors who do not make assumptions about students based on race or ethnicity. Counselors must provide all students with equal information about career options, offering support as needed but encouraging students themselves to take responsibility for choosing their career directions, based on their personal interests. At the same time, counselors must guide students toward their goals by assisting with the selection and most effective sequence of courses to meet college entrance requirements.

Two-year colleges should be presented as an option. Students who begin to show an interest in science in the later high school years (and therefore have not taken courses necessary for college admission) should be encouraged to attend community colleges in order to develop competencies necessary for baccalaureate or graduate study in scientific fields.

Parents must be involved in their children's education and development. Working in tandem with teachers, parents play a critical role in their children's education and interest in pursuing science careers. Supports must be available to assist parents in taking an active role in their children's education and development, especially for children from disadvantaged homes. For example, support systems should be made available to low-income or single parents who are less available to their children because they must work long hours to support their families. Paid time off might be provided for parents to attend conferences or school activities during their normal working hours. In addition, communication with parents should include discussion of college preparation options.

Parent-teacher collaboration must be increased and expected. Parent-teacher relationships must be established early in the school year and parents must be encouraged to communicate with teachers throughout the school year. Parents of all students must be kept abreast of the science curriculum so that they can encourage their children to take an interest in science. In addition, reinforcement of minority students' self-concept and self-esteem must be a joint effort between parents and schools, thereby cultivating a positive school-home relationship. Parents of minority students must be educated about how to ensure that their children receive from schools any extra support and assistance that their children may need. For example, parents must know when and how to obtain tutoring or mentoring for their children if they cannot provide it themselves.

Working scientists, especially minority scientists, should participate in school outreach activities in order to develop students' interest in science careers. Just as firefighters or police officers visit classrooms, working scientists should share their experiences with students, especially those of racial and ethnic minorities. Appropriate, effective incentives must be provided to encourage scientists to participate in school programs, including career days. NSF could establish a Web site to link schools and practicing scientists who are available to participate in school-based activities.

Public-private partnerships must be encouraged. Public-private partnerships must be used to encourage university and industry scientists to "adopt" school science programs. As part of the programs, the scientists could visit the schools, teach labs, and provide continuing education opportunities for teachers, for example.

Teachers must emphasize that not all of science is "known" and that the textbooks do not represent all that is or can be known about science.

Students in grades 7 through 12 must be introduced to the "scientific method." Middle school and high school students must be exposed to the concept of hypotheses and the scientific discovery process in order to understand why and how scientific investigation proceeds. Teachers must emphasize that not all of science is "known" and that the textbooks do not represent all that is or can be known about science. Science teachers must also reinforce the importance of good writing and oral presentation skills in reporting scientific discoveries.

Television should be used creatively to teach science and to provide minority role models. Television is a powerful tool to reach youth; therefore it should be used extensively to inform young people about the different aspects of scientific discovery, as well as to present minority scientists as role models. Television producers should be encouraged to portray scientists in a positive manner. In addition, television programs should concurrently address social issues that confront minority children and adolescents.

Minority scientists must be encouraged to seek academic positions, and universities must proactively seek qualified minority scientists as faculty members.

Materials depicting minority scientists must be present and visible in classrooms. More multiculturally oriented books, videotapes, posters, and other materials must be used in the curriculum or made available in classrooms to portray persons of racial and ethnic minorities as scientists. Teachers should reinforce the diversity of the scientists illustrated in these materials.

Undergraduate and Graduate School

More minority faculty members are needed in university science programs. Minority faculty members offer unique and valuable perspectives, making the academic programs in which they teach more attractive to minority students. Such faculty are too few in number and often are burdened with multiple demands. In addition to their teaching and research responsibilities, minority faculty members often are sought out as advisors and mentors, particularly by minority students. Therefore, minority scientists must be encouraged to seek academic positions, and universities must proactively seek qualified minority scientists as faculty members.

Mentors must be provided at all levels, beginning with undergraduate school. Peer mentors can provide minority students the support, encouragement, and impetus needed to train for, enter, and succeed in science careers. At the undergraduate level, junior and senior students should serve as peer mentors for freshmen and sophomores, helping younger students to maneuver through the university system and advising on how best to position themselves for graduate school. Likewise, graduate students should serve as mentors to juniors and seniors, and postdoctoral fellows to both graduate and undergraduate students. Incentives should be provided to mentors, and mentors should be held accountable for their activities as mentors.

Students must learn good study habits. Undergraduate students often lack good study habits and time management skills. Programs must be established to assist students in these areas, thereby building their competitiveness within the undergraduate environment and preparing them for graduate school. For example, peer mentors could help students to improve their study skills.

Minority students will benefit from assistance in learning "the system." Many minority students, especially those whose parents did not attend college, need assistance in learning how to maximize their undergraduate experiences. Junior- and senior-level peer mentors should advise freshmen and sophomores about the best sequencing of courses, how to find lab experience opportunities, and how to improve the possibility of graduate school admission, for example. Working with more experienced students, young minority undergraduates could build their networks and become exposed to positive role models.

Committed faculty mentors are a determinant of success. Faculty mentors can provide undergraduate and graduate students important guidance for continued education and career planning, and can help them to develop contacts and a network for the employment search. This guidance is particularly important in fostering minority students' success in pursuing science careers. Incentives are needed to encourage faculty members to serve as mentors to minority students, and faculty mentors must be held responsible for students' progress toward their goals.

Research experience is paramount at the undergraduate level. The opportunity to participate in hands-on research is critical in undergraduate students' decisions to pursue further training and to enter science careers. However, because their networks with fellow students and faculty members are often smaller than those of other students, minority students may be unaware of research experiences that are available on campus or elsewhere. Therefore, efforts to make minority students aware of hands-on research opportunities are needed. Programs such as NSF's Research Experiences for Undergraduates and the National Institutes of Health's Minority Access to Research Careers (MARC) are valuable in that their stipends enable students to gain research experience in laboratories at their own universities or at distant institutions during the summer months.

Graduate school programs must place greater emphasis on learning to teach. Graduate students who plan to work in academic environments must learn to conduct research as well as to develop their skills as effective teachers. Teaching, and the development of teaching skills, must be regarded more often as an important part of academic culture and training.

More broad-based skills training must be offered. Minority students often find themselves unprepared for the next stage of their training and career preparation. Graduate schools and NSF could support programs to assist those in training with essential skills in science writing, oral presentation, and grant proposal writing. In addition, students must be encouraged to explore career alternatives, such as research development, policy making, science writing, and patent law.

Funding is essential for many minority students who plan to obtain graduate degrees. Minority students are hesitant to borrow money to attend graduate school, and many base their decisions to continue their educations on the availability of external funding. Therefore, undergraduate minority students must be made more aware of funding opportunities, including but not limited to special funding for minorities. Universities, organizations such as NSF, and mentors must ensure that minority students are informed about how to locate and successfully apply for funding.

Postdoctoral Fellowships and Employment

Postdoctoral fellowships provide minority scientists with opportunities to work in prestigious, highly respected labs. The existence of fellowship funding, such as that offered by NSF, enhances the ability of minority scientists to work in highly regarded labs, which in turn opens doorways and creates pathways for greater opportunities. Working in high-quality scientific environments allows postdoctoral fellows to conduct research and work with respected scientists, as well as to present papers at major scientific meetings, to gain valuable experience preparing grant applications, to learn how to manage a lab, and to expand their

"What I found most rewarding about being in the NSF postdoctoral program was the other postdocs. I really enjoyed listening to their presentations because they do great science, they love their work, and they know how to convey both the science and the love."

–Elizabeth Mezzacappa, PhD

professional networks. In addition, mentors and other scientists at prestigious labs can assist fellows in securing positions in academia or industry by providing essential contacts and letters of recommendation.

"One of our responsibilities as NSF Minority Fellows is to help the people with whom we interact to better understand the advantages of increasing diversity in science. The varied perspectives and approaches that are a result of diversity help to accelerate scientific discovery, while increasing the participation of individuals in science from various ethnic groups expands the talent pool and provides a sense of inclusion."

—Andrew W. Singson, PhD

Fellowship applicants must learn to maximize their skills and backgrounds. Minority scientists applying for postdoctoral fellowships must distinguish themselves in their applications. Many applicants do not know how to prepare and package an application to their best advantage. Excellent written communication skills are needed to convey not only the applicant's academic qualifications and experience, but also his or her determination and goals in pursuing a science career. Mentoring and workshops could constructively assist minority graduate students in preparing successful applications.

Mentoring is important at the postdoctoral level. Postdoctoral fellows benefit from the knowledge, experience, and professional contacts offered by their mentors. Mentors can advise on how to seek employment, write a successful curriculum vitae, establish and manage a research lab effectively, review manuscripts, write grant proposals, develop one's own scientific niche, and market oneself as a scientist.

Minority scientists need to be more visible within professional organizations. Few minority scientists achieve high-profile positions in professional societies. Minority scientists must find ways to break through the "glass ceiling" within these organizations, and the organizations themselves must more proactively seek out minorities as leaders. ■

Access to Mathematics and Science Careers for Underrepresented Minority Students: Research Findings and Explorations

Dr. Beatriz Clewell
The Urban Institute

In order to participate in math and science careers, students must first develop an interest in math and/or science, and acquire the skills necessary to perform well in those courses. Then they have to take a sufficient number of courses in math and science in high school and of course that means being in an academic track. It is very unusual for someone who is not in the academic track to go on to a math/science career. Then they have go into college—to enroll in college, declare a math or science major, and persist through college until they graduate. When you think of all the possibilities for people to fall out of the so-called "pipeline," there is no real secret why there are so few of us in math and science.

There has been quite a bit of research done on the math and science talent pool because people want to know where they really should target their efforts, their intervention efforts. We know that it [the talent pool] reaches its maximum size before the high school level but migration still occurs through grade 12. Even though people may not have been in the math and science pool in the early years, they can still get in up to grade 12. However, by maintaining an interest in math and science in elementary and middle school, people can still retain membership in the pool. But by high school, if their skills have not increased and they are not doing well in the courses, there really is little chance of them going into math and science careers. So by high school you not only have to be interested and maintain your interest, but you also have to do well in your courses and you have to be thinking about college.

Four barriers have been identified that impede the access of minority students to math and science careers. One of those is negative attitudes towards math and science. There are a lot of data from a national assessment of educational progress, for example, where first graders, eighth graders, and 12th graders are asked about their opinions and their feelings and interest in math and science. Minority students and female students tended to say that they do not understand the relevance of math and science to their lives, to the future of humanity, or to society. There has been some evidence that that is changing, that minorities are tending to like math and science more, but we are not really sure where that's going.

When you think of all the possibilities for people to fall out of the so-called "pipeline," there is no real secret why there are so few of us in math and science.

The second barrier is a lack of information about mathematics and science careers. Many minority students have never seen a scientist. They have no idea what a mathematician does or how mathematics can be used in science. One of the most significant indicators of minority students going into math and science careers is whether or not they know a scientist personally.

Third, minority students tend to not do well in math and science, although data show that scores are going up, which we find very encouraging.

Fourth, the failure to participate in higher level math and science courses in high school is a barrier. Minority students are underrepresented in the academic tracks and that's where you get the high level math and science courses. When I [visited] high schools, many of them did not offer advanced placement courses in math, and when I asked why, they said, "Well, there is no one to take them." So even if minorities wanted to take higher level courses in some of these cases, they would not have access to them.

Minority students and female students tended to say that they do not understand the relevance of math and science to their lives, to the future of humanity, or to society.

I am going to talk about four research projects. The first two have to do with the middle school level and I will take kind of a pipeline approach. The third deals with choice of a math or science major and undergraduate education, and the fourth concerns persistence in doctoral education. The fourth really focuses on the efficacy of financial aid and financial aid packaging in helping minority students to persist through doctoral programs. The first two have been completed and the second two are in progress right now.

In the 1980s, a lot of attention [was paid to] intervention programs and the importance of intervention programs in expanding the pool of minority scientists. People realized that minorities were not participating in math and science. At that time a whole spate of intervention programs sprang up. Because people did not know a lot about what to do or how to do it, they tended to focus on the wrong part of the pipeline—they focused on high school. As we know, high school might be a little too late. Those are good programs to retain people in the pipeline but they are not good to expand the pool.

So finally, people started thinking, "Well, why don't we go higher in the pipeline? Why don't we try to increase the number of students at the middle school level who might be interested in these careers?" The Ford Foundation came to me (I was at the Educational Testing Service at the time) and asked me to look at all the math and science intervention programs in the country from grades four through eight that focused on serving minority and female students.

Through a referral system, we sent mailings to about 2,000 organizations and universities and schools. [Of them] we surveyed 163 [intervention] programs and asked what their target populations were. Thirteen percent targeted females only, 33 percent targeted minorities only, and 54 percent targeted minorities and females. We asked them what subject areas they focused on and the most prevalent were the ones that focused on all three subject areas: math, science, and computer science. I thought that it was interesting that there are many more math intervention programs than science intervention programs, and I really don't know the reason for that.

We also asked them to give the distribution of their students by grade level. We found that a lot of the students were in the eighth grade and that the fourth grade had the lowest percentage of participants.

California had the most programs of all and some very, very notable programs have come out of California. Many of the states that have very high American Indian populations were not represented, so that means these students did not have access. In the Northeast, New York had the highest number of programs, but the District of Columbia did not do badly. In the Southeast we noticed that Georgia had many more programs than the other states.

We also asked [the intervention program staffs] what kinds of things they did with students, what their prevalent activities were. Hands-on experiences were the most prevalent and, unfortunately, direct instruction was also prevalent. I hope that has changed. A lot of the counseling was around career counseling and what courses to take in high school. Role models were very big, and there were guest speakers and a lot of field trips.

As a result of this [survey] we made recommendations to the Ford Foundation on our findings. One of our recommendations was that they increase the number of programs serving girls and minority students. There were a lot of gaps in service in intervention programs around the country. In the South, where a large percentage of the enrollment is African-American children, there were very few programs except for in Georgia. In the Southwest, where there are a lot of Native American children, there were very few programs. So we recommended to the Ford Foundation that they increase their funding for programs in those areas.

A second phase of this project resulted in a widely disseminated directory of programs. It was something that project directors could use to identify other programs that were doing similar kinds of things or that schools could use to refer their students to programs in their areas. The Ford Foundation asked us to do a more in-depth study of the programs and we identified 20 programs that had done evaluations. We visited 20 and we picked 10 of them to do in-depth case studies. We spent about a week onsite at one point and then we went back in the summer, talked to people, and observed classes. We wrote about it in a book that was published a few years ago.

The study identified effective characteristics of intervention programs and talked about some of the theory and the research that undergirded some of the approaches and strategies. One of the things that really bothered us after having done all this work on intervention programs was the question of “What next?” Intervention programs only can service a few students. What about all the other students who are not served? We really felt that we needed some way of getting these wonderful strategies into schools. But of course, along came the reform movement standards and a lot of the things that are happening now I feel really good about.

One of the most significant indicators of minority students going into math and science careers is whether or nor they know a scientist personally.

I would like to go on now to the next research project, which focuses on undergraduate students. This one is in progress; we are actually just beginning and have not even collected the data yet. It is funded by the [Alfred P.] Sloan Foundation and is called “Project Talent Flow.” The study objectives are to document why African-American and Latino [undergraduate] students of high ability choose non-science, engineering, and math majors. We want to see the kinds of experiences that they had before going into college that led them to think that math and science might not be good fields for them. We also want to look at gender differences and differences between racial/ethnic groups. We want to identify crucial barriers and learn about factors that might encourage [underrepresented minority students] to choose a math and science career or major and then, of course, recommend steps that institutions might take to increase the number of high-achieving minority students in these fields.

Teaching assistant experiences introduced students to some other faculty and, in some departments, to professors in areas that they would not have known otherwise. . . .

We are going to use the critical incident method to do this study. [This method] asks people to identify incidents that were crucial in influencing their behavior. The critical incident is really focused on a behavior. You [ask individuals to] think about the actual minute when something happened that changed their behavior. We have already done some field tests, and I can tell you it is not easy because people tend to answer in a very general way. Getting them to focus in on a specific critical incident that affected their behavior subsequently is very difficult. We are looking for students, minority students—African American and Latino—who have made 550 and above on the math SAT and who have not gone into math and science.

I would like to go on to the next study, the study of doctoral persistence, and I think that this is probably close to the hearts of a lot of you. This study is funded by the National Science Foundation. We are further along in this study in that we have already collected data from one of the two graduate schools. We want to know how different types of financial aid affect time to degree and completion of doctoral degrees. We defined minority as African American and Latino. We also want to know how the timing of different types of financial aid affects degree completion. By timing I mean is it better to have teaching assistantships first and then fellowships and then research assistantships—how is it best to package this aid? We want to know how these effects vary across different types of fields.

This will be a qualitative and quantitative study. We have surveyed all students who have entered social sciences, natural sciences, and engineering doctoral programs since 1985, so there are several cohorts of students. The qualitative part of the study really focuses on current minority students, so we have held focus groups with minority students in one institution. We talked to chemistry, engineering, and psychology students. We also interviewed several faculty members in the department, the graduate chair, and several people at the graduate school because we wanted to know what the policies were and their perspective from the faculty and administrative side.

One of the things we asked [the doctoral] students about was what their expectations were. Many of the students did not anticipate receiving a fellowship and they did not apply [for one] before they entered the university, which we found kind of interesting. They assumed that they would be supported in some way, either by their major adviser or whomever they picked to work with. We also found that many of the graduate students or doctoral students thought that their salaries were inadequate; that was no surprise. We asked what they thought were the advantages of different kinds of financial aid. The main advantage of fellowships that they gave us was that it gave time to concentrate on their studies. They also were eligible for in-state tuition and they felt that it helped them to gain access to labs that they might not have been able to have access to. All they did was go to a faculty member and say, "I am supported. You don't have to do anything. Can I join your lab?" [The faculty member] would say, "Sure." [The students] also felt that it was a good thing to put on their curriculum vitae, that they had had this fellowship. It was prestigious.

There were some disadvantages [of fellowships. The students] felt that cost-of-living increases were not included in the multi-year fellowship, health benefits were not included; they did not know about taxes. Some said that they felt somewhat alienated from their other classmates because they had a fellowship. They felt that their white classmates had the attitude that they got a fellowship because they were minority; that was very widespread.

We asked [the doctoral students] about research assistantships and one of the biggest problems was faculty control of research assistantships. [The students felt that] if they had research assistantships they were totally dependent on the faculty member. In some cases they got meaningful work and in other cases they did not. They felt that they gained the opportunity to publish and attend conferences, that sometimes their dissertation topics came out of research assistantships, and that they had concentrated time in the labs. Some students indicated that it is nice to be paid to do something they enjoy. Another advantage of research assistantships was that [the students] got health benefits. Disadvantages of research assistantships: They could be very stressful if [the student is] being pressured to get results. Another one that I thought was interesting was that some students felt that research assistantships forced students to focus too soon on a topic rather than receive a broad exposure to what was out there so they might become locked into a choice of dissertation topic too soon.

Teaching assistantships. We felt that people would be really against teaching assistantships but a number of advantages were mentioned. [The students] felt the primary advantage was that people gained experience in teaching, and some students said that they actually realized they wanted to be faculty members instead of researchers. They felt that [teaching] builds on academic skills because when you teach someone you are also reinforcing your own knowledge of something. Teaching assistant experiences introduced students to some other faculty and, in some departments, to professors in areas that they would not have known otherwise, and some of the students really enjoyed getting to know the undergraduates. The other side of the coin is the amount of time that teaching assistantships demand.

We asked about the packaging of financial aid—what was better up front and what was better later on. We got a whole range of responses and there was consensus on only two points. Most students agreed that teaching assistant experience should be early in students' studies before they become too deeply involved in research. The majority of students felt that they needed fellowships at the dissertation phase. We concluded from this that the packaging depends on the field of study and a lot of different other variables.

We also asked about [students] who had dropped out. Most people did not drop out because of academics or because of financial aid. It was usually a combination of several factors and none of the students had ever considered leaving because of finances. Something we heard again and again was, “I have invested so much in this, I am not about to leave now.” We did find that students who were well-supported were the most satisfied and were, according to them, the most productive.

So these are our preliminary findings from this study. We still have to analyze the survey data and to collect the data from the other graduate school, which we will be doing this fall.

Production of Chicana and Chicano Doctoral Scientists: Status, Barriers, and Policy Recommendations

Dr. Daniel Solorzano
University of California, Los Angeles

I want to take you on a journey with me for the next couple of minutes. These issues are very important to me. I'm sure they are important to you and, as you know, in our discussion of these issues we gain clarity and hopefully we can arrive at some solutions to solve some of the problems that I'll be talking about. One of the questions that I continually ask myself and I know other people have asked this in the past is: Who is doing science in the 1990s? Another question is: Who will do science in the 21st century?

I'm going to talk a little bit about the demographic characteristics of Latino populations because I think it is absolutely critical that we clearly define populations. By keeping our definitions broad, we mask some real differences between populations and within populations. As a sociologist I want to talk a little bit about those issues. I then want to talk about the state of Chicana and Chicano doctorate production in the physical, life, and engineering sciences. Finally, I want to talk about the baccalaureate origins of Chicanas and Chicanos in the sciences.

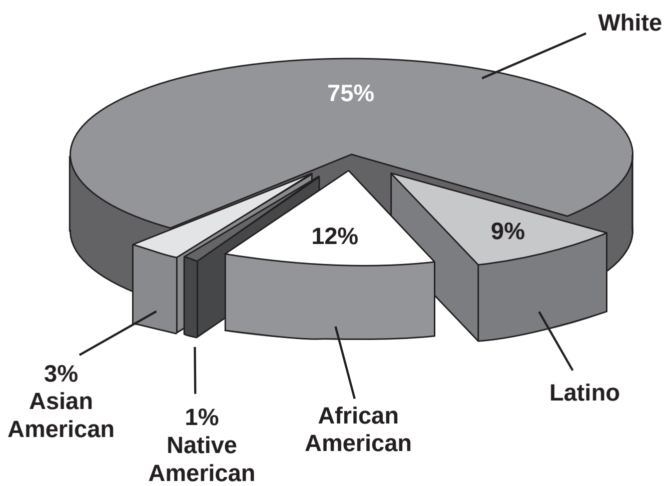
I'd like to place this within a certain context and I think in 1996—in September of 1996—you have to place minority doctorate production within the context and politics of affirmative action, both nationally as well as in my state, California. At my university, the University of California, the regents passed a resolution in July of 1995 that changes the admissions requirements for minorities and women. It was called SP-1. Section 2 of the resolution states that "Effective January 1, 1997, the University of California shall not use race, religion, sex, color, ethnicity, or national origin as criteria for admission to the university or any programs of study." This proposal is going to have a dramatic effect on my undergraduate students as well as my doctoral students, and this concerns me.

The second political issue in my state that is of great concern to me is Proposition 209. In November of this year the state of California is going to vote on a proposition that will forbid the use of race and gender in any sort of state function. It is troubling to say the least. I'd like to hope that the forces supporting affirmative action would rally, would form coalitions, and would hopefully defeat Proposition 209. It is a troubling proposition because I'm afraid that other states are looking at how California moves on this issue. Once again, California—for better or for worse—is taking a position that is going to have an adverse affect on underrepresented minorities and women in terms of all aspects of state policy. As you can tell, I am a supporter of affirmative action. I have been a beneficiary of affirmative action and I have been a critic of affirmative action. Some of the critics of affirmative action argue that it only benefits people in the middle class, but the data do not support that position.

To give you a little bit of information about myself, I am the son of working class parents. My father was a baker. He baked Mexican bread for many, many years along with his father, my grandfather, and his father, my great-grandfather. All of my uncles were bakers and I probably would have gone into that very honorable profession but for a couple of different deviations in that pipeline. My mom was a telephone operator at Sears Roebuck for many years. They were not from middle class origins. They were basically working class from East Los Angeles.

FIGURE 2

Racial and Ethnic Populations in the United States: 1990



Source: U.S. Bureau of the Census. (1992). 1990 Census of Population: General Population Characteristics, United States Summary (1990 CP–1–1). Washington, D.C.: U.S. Government Printing Office.

I arrived at the university as an undergraduate in 1968 when affirmative action was just beginning. Universities were just opening up the doors to people like myself who had previously had been kept out. I use my older brother as an example because my older brother is a sheet metal worker. He puts in air conditioning systems in homes, offices, and businesses, and he is equally as bright as myself if not more. He is a much harder worker than myself. He cares very much about the quality of his work. I learned that from him. But in 1962, when he graduated from high school, there was very little opportunity. But for a fluke of birth or timing he may have been up here making this presentation instead of me. I arrived at a different time. I was able to take advantage of the doors that were opened up by a small number of people who came before me, and I would like to think that I am trying to open up the door for people who are coming behind me.

Demographic Characteristics of Latino Populations

The next step [in my presentation] is the demographic characteristics of Latino populations. One of the things that we need to do is try to understand who this population or who these groups are. Latinos make up about 9 percent of the overall population, African Americans about 12 percent, Native Americans about 1 percent, Asian Americans approximately 3 percent, and whites around 75 percent (see Figure 2). However, within the Latino population, Chicanos, or Mexican Americans, make up about 64 percent, Puerto Ricans about 11 percent, Cubans about 5 percent, Central and South Americans about 14 percent, and other Latinos about 6 percent (see Figure 3). Two out of every three Latinos are of Mexican origin—Mexican ancestry or what I call Chicano. (If I was making this presentation 10 years ago, my grandmother would just cringe because she would never use that term. It is a term that goes back to the turn of the century and is used in a different context, but it is a term that I choose to use in the context of my own research.)

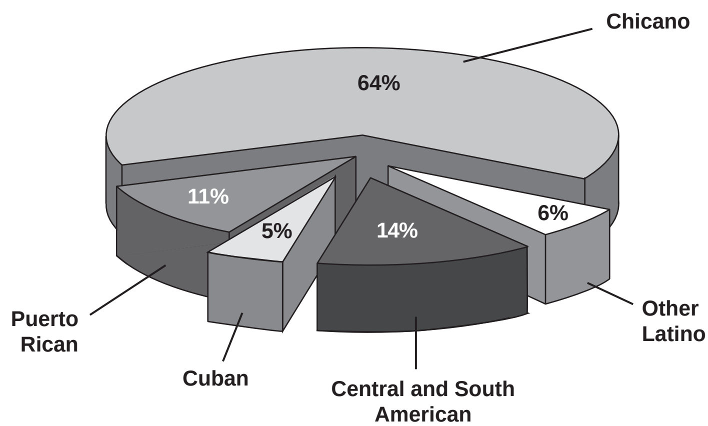
The Chicano population is mainly concentrated in the five southwestern states, although that is changing. There are very real differences [within Latino subgroups] and I think that by aggregating them together as Latinos, you mask those differences. The median age for Chicanas and Chicanos is about 24.4; the median age for whites is 35.2. But the median age for Cubans, one of those Latino subgroups, in 1990 was approximately 37 or 38 years. So again, they are very different populations than the Chicano population.

I also would argue that the Chicano population is growing. The median age is one reason why it is growing. It is an extremely young population (i.e., 24.4 years) as compared to the white population (35.2 years). It is also a very fertile population. Among women between the age of 35 and 44, Chicanas have about 2.9 children per woman. Whites have 1.9, a little less than two, which is a very dramatic difference between the two populations in terms of projection into the future.

The third point is immigration. Clearly, the largest number of documented immigrants are coming from Mexico into the United States. The other issue is undocumented immigration. Both documented and undocumented immigration relate to the history and geography of this population or these populations in the southern part of the United States. The Mexican population is one of the few populations that were conquered by the United States. The U.S.-Mexican war culminated in 1848. Historically, these groups have had very different experiences. There is also another factor, the 2,000-mile border between the United States and Mexico. It is very real and very fluid. You should know that up until 1924 there was no U.S. Border Patrol so people could move back and forth across the border at will. The magnet on this side of the border is work; people come looking for work and there's work here for them.

FIGURE 3

Latino Subpopulations in the United States: 1990



Source: U.S. Bureau of the Census. (1992). 1990 Census of Population: General Population Characteristics, United States Summary (1990 CP–1–1). Washington, D.C.: U.S. Government Printing Office.

The State of Chicana and Chicana Doctorate Production in the Sciences

James Conyers, a sociologist, has stated that empirically based studies of black scholars are needed to "establish a baseline from which practitioners and researchers in the years to come can evaluate the magnitude, direction, and significance of changes which seem to occur with respect to black professionals, their social education origins, and the process by which they are recruited." In 1986, James Conyers basically challenged me—challenged us—to come up with baseline data.

When I looked around, I realized there were no baseline data for Chicanos—absolutely none—and there had been no baseline studies that would look at PhD production for Chicanos, so I set out to do that. These data actually come from the National Research Council, from the Doctorate Records Project. Table 1 looks at the number and percent and something I call parity for Chicana and Chicano PhDs: In all fields and specifically in the

TABLE 1

Number and Percent of Chicana and Chicano Doctorate Production by Science Fields: 1980-1990

Females

	Number	Percent	Parity
Overall	751	0.7%	0.16
Physical Science	33	0.4%	0.09
Life Science	66	0.4%	0.09
Engineering	12	0.7%	0.16

Males

	Number	Percent	Parity
Overall	1189	0.7%	0.14
Physical Science	105	0.3%	0.06
Life Science	127	0.4%	0.08
Engineering	62	0.3%	0.06

Source: Solorzano, D. G. The baccalaureate origins of Chicana and Chicano doctorates in the physical, life, and engineering sciences: 1980-1990. *Journal of Women and Minorities in Science and Engineering.* 1(4), 253-272.

physical sciences, life sciences, and engineering sciences. One of the problems that I have with these data, and the reason why these data only look at the years 1980 to 1990 is that prior to 1980 the way we defined this population was problematic. In fact, up until 1980 there was no uniform definition of Chicanos.

Seven hundred and fifty-one Chicana PhDs were produced during the period 1980 to 1990. They represented about seven-tenths of 1 percent of all women PhDs produced during that time period. During that same decade they were approximately 4.5 percent of the female population. If you divide .7 by 4.5 you come up with a ratio I call a Parity Index, the number one being parity and zero being no parity.

In the physical sciences only 33 Chicana PhDs were produced in that 11-year period. They represented about four-tenths of 1 percent of all female PhDs produced in the physical sciences and a parity index of .09. In the life sciences there were 66, double the number in the physical sciences, yet still they only represented four-tenths of 1 percent, a parity index of .09. In engineering, there were 12 in that 11-year period. They represented seven-tenths of 1 percent, a parity index of .16. You can actually use that parity to determine how much we need to increase the numbers to reach parity, how much effort we need to put into our colleges to increase the number of people who finish and receive PhDs in these science fields. For instance, in the physical and life sciences, we would have to increase Chicana doctorate production 11-fold to reach parity. Quite a daunting task.

Although the numbers look a little bit better for males, they are not much better. Overall, 1,189 male Chicano PhDs were produced between 1980 and 1990. They represented seven-tenths of 1 percent of all male PhDs produced during that same period and a parity index of .14. In the physical sciences, there were 105, in the life sciences there were 127, and in engineering there were 62.

For purposes of my presentation, I show the African-American, the white, and the Chicano and Chicana parity numbers (see Figure 4). One can observe how African-American women and Chicanas are attaining PhDs relative to white women in terms of this Parity Index. White women in all of these different areas are above parity relative to women of color but not relative to white men. White females are above parity, and Chicana and African-American females are well below parity in the physical, life, and engineering sciences. White males fall below parity in only one field, engineering. However, Chicano males are the least represented in each of these three major fields in PhD production.

In order to reach parity, it is going to take tremendous production for the next generation of both African-American and Chicana and Chicano scientists. In other words, to reach parity or "one," it is going to take a lot of effort by people like yourself, by groups like NSF, by organizations like the Ford Foundation, and at a time when these types of affirmative action programs are not very popular. That's a real concern to me.

The Baccalaureate Origins of Chicana and Chicano Doctorates in the Sciences

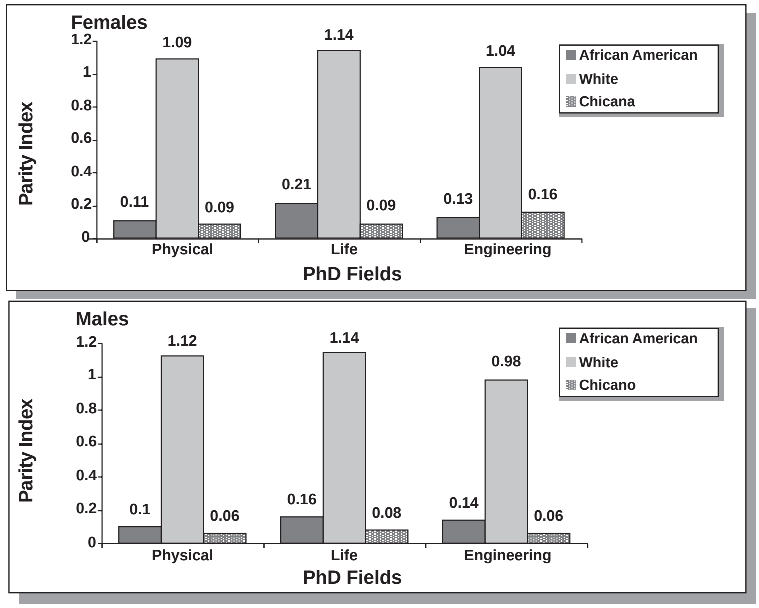
The data in Figure 5 indicate where Chicana and Chicano doctoral students in the sciences do their baccalaureate work. The baccalaureate is an extremely important filter point to the PhD. Indeed, getting a baccalaureate in a science field is an important step in getting a PhD in science. It is a very rare person who received a BA in political science or sociology and then went on to get a PhD in mathematics.

I broke down the data into three types of baccalaureate institutions: Research I institutions, Research II institutions, and Comprehensive I and II. The Carnegie Foundation for the Advancement of Teaching designates every college and university in the United States with a specific Carnegie classification. Figure 5 provides examples of the racial/ethnic and gender differences among the three types of institutions. These data are for the top 50 institutions whose students continue on to receive PhDs.

Twenty-nine percent of African-American women who went into those three science

FIGURE 4

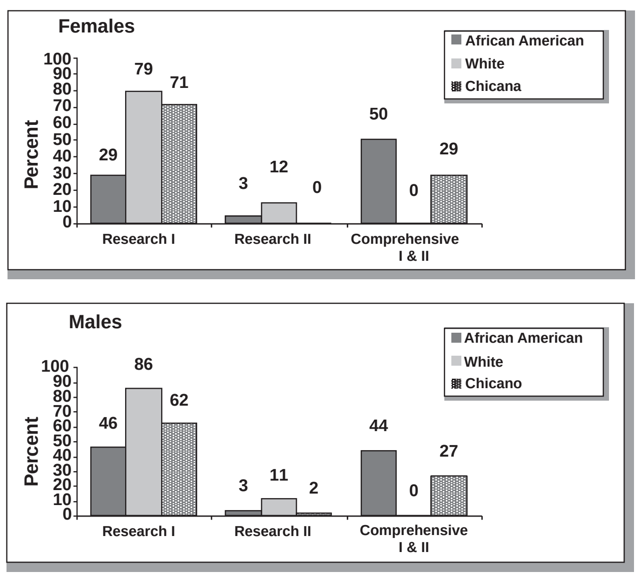
Doctoral Parity in Science Fields by Race: 1980-1990



Source: Solorzano, D. G. (1994). The baccalaureate origins of Chicana and Chicano doctorates in the physical, life, and engineering sciences: 1980-1990. *Journal of Women and Minorities in Science and Engineering.* 1(4), 253-272.

FIGURE 5

Baccalaureate Origins of Science PhDs by Racial/Ethnic Group: 1980-1990



Source: Solorzano, D. G. (1995). The doctorate production and baccalaureate origins of African Americans in the sciences and engineering. *Journal of Negro Education.* 64 (1), 15-32.

fields did their baccalaureate work at Research I institutions. Seventy-nine percent of white females and about 71 percent for Chicanas did their baccalaureate work at Research I institutions; although the percentage of Chicanas is lower than that for whites, it is much higher than that for African Americans (29 percent). For Research II institutions it is 3 percent of African-American females, 4 percent of white females, and 0 percent of Chicanas. Finally, 50 percent of African-American females did their undergraduate work at Comprehensive I and II institutions. Also, if you look at the list of the top 50 institutions, for African-Americans, the top 23 institutions are historically black colleges and universities. Clearly, historically black colleges and universities have played and continue to play a very important role in the production of African-American scientists.

We need to understand that K through 12 education has critical filter points in the production of the next generation of scientists.

As for males, about 86 percent of whites, 46 percent of blacks, and 62 percent of Chicanos did their baccalaureate work at Research I institutions. Again, this is a similar pattern but slightly less in Research II institutions. Finally, 44 percent of black males did their baccalaureate work at Comprehensive I or II institutions, while 27 percent of Chicanos and no whites received their baccalaureates from these institutions.

David Goodstein made this comment in 1993 in a journal called *The American Scholar:* "The PhD shortage is an illusion, a kind of mirage caused not by the hot sun but by too much staring at statistics unmoderated by serious thought. What we face instead is a chronic, systemic oversupply of PhDs, a rising tide of PhDs that we seem helpless to stem." I am not going to argue that there is or is not generally an overproduction of PhDs in science, but clearly for Chicanas and Chicanos, there was not a shortage. In fact, it would take anywhere from six to 17 times in production to increase the numbers to achieve parity.

Professor Goodstein goes on to argue that he has a solution to this oversupply. He says, "What would be required for ZPG (zero population growth) in academic science? The answer is not hard to find: Each professor in a research university should produce, on average, during an entire career, no more than one student who would become another research professor." Again, for those of us interested in increasing the numbers of underrepresented minority PhDs in science, this is unrealistic and overly simplistic. Clearly, this is the sort of issue we need to deal with.

Policy Recommendations

I want to close with my policy recommendations.

Number 1: We need to understand that K through 12 education has critical filter points in the production of the next generation of scientists. Therefore, we must support those programs that are trying to increase the numbers of underrepresented minorities who continue on in the science field. I sit on the University of California (UC) task force that is looking at the eligibility of California high school students for admission to UC, and we have found that less than 4 percent of graduating Latino high school students are eligible for the University of California, compared to 13 percent for whites, 5 percent for blacks, and 32 percent for Asian Americans.

In studying the high schools in California, we found many schools that service mainly Latino and African-American students that did not offer advanced placement (AP) courses, honors courses, and what we in California call the "A-F" required courses. Basically, these kids went to school with little or no opportunity to take these crucial courses for college admission. Yet we know that if you take an AP course, it actually has an inflating impact on your GPA. Clearly, if students haven't been given the opportunity to take these courses, they are put at a disadvantage.

Number 2: We need incentives for both the promotion and tenure of faculty members who mentor underrepresented minority students at the undergraduate and graduate levels.

Number 3: We need to increase the number of underrepresented minority faculty in the sciences. These faculty can and do serve as role models for the next generation of scientists. They can also serve as members of admissions, fellowship, screening exam, and dissertation committees. It is absolutely critical that you have minority representatives at that table when you look at files for admissions to your programs. If I had not been on the admissions committees at my institutions as well as on fellowship committees for the Ford Foundation, National Research Council, and NSF, I am not sure minority students would have gotten a fair read.

Screening exams are a critical filter point at the doctoral level and it is really important that we sit on screening exam committees and that we give a fair read to all students. Finally, dissertation committees. I have had experiences in which underrepresented students in my department have a difficult time constituting dissertation committees. It is really sad but I think that there are good people at my institution and at your institutions who understand what is happening and support these students.

Number 4: We need to hold universities and departments accountable for the production of underrepresented minority undergraduate and graduate students.

Number 5: We need to identify, support, and acknowledge those undergraduate and graduate institutions that are producing the next generation of minority scientists. I would also argue that there are important individuals who are doing more than their fair share of producing the next generation of Chicana and Chicano scientists or minority scientists. Some of them are Faculty of Color, some of them are not, but we need to acknowledge them and support them. We also need to support funding programs, such as those sponsored by the Ford Foundation and NSF, because they are helping to produce the next generation of minority scientists. I think at this particular time, instead of backing down, we need to be more bold in our support of affirmative action and affirmative action type programs like the NSF program.

We need incentives for both the promotion and tenure of faculty members who mentor underrepresented minority students at the undergraduate and graduate levels.

Perceptions of Faculty Research Preceptors Toward Minority Undergraduates in a Summer Research Program

Dr. Henry T. Frierson, Jr.
University of North Carolina, Chapel Hill

This is an examination of perceptions that faculty have regarding minorities who participated in a summer research program at the University of North Carolina. The program, the Summer Pre-Graduate Research Experience (SPGRE) Program, targets minority students, of whom about 85 percent to 95 percent have been African Americans. A number of Mexican-American students, Puerto Rican students, and American Indian students have also participated.

The program has been in existence since 1988 and I have been involved in it from its inception, and have been the director since 1989. From 1988 to 1996, 273 students have participated. Half a dozen of those students have participated twice, so we have had an approximate average of 30 students per year who participated in the program, but in the past several years, the number of participating students has been in the 40 to 50 range. This program came into existence shortly after a large increase in such summer research programs which occurred in the late 1980s. Most of the programs are funded by external sources. The National Science Foundation (NSF) has played a major role, as has the National Institutes of Health and some private funding agencies.

SPGRE students come from a wide range of fields. When I set up the program, I noticed that students in the so-called non-science areas were pretty much being ignored—non-science being primarily in such areas such as philosophy, English, history, and to some extent the social sciences. For purposes of this presentation, I categorized faculty into non-science versus science. (With more data collection, I am going to separate the divisions into three: the humanities; the sciences which would [include] life sciences, natural sciences, physical sciences, and engineering sciences; and the social sciences or behavioral sciences). The students apply to the program and they are selected primarily by the faculty with whom they are going to work. Thus, instead of assigning students to faculty or assigning faculty to students we try to set up a situation whereby the students and faculty communicate before the program actually starts.

There were 51 faculty for this particular study and they served as preceptors, or mentors, for SPGRE students. The faculty were interviewed at the ninth and 10th weeks of the [10-week] program. They were asked a series of questions regarding their impressions of the program, some background information, and their assessment or perceptions of the students with whom they had worked.

One of the questions dealt with discerning the assessment of the faculty members' initial expectation of the students, that is, what expectation did they have of the students before they arrived on campus. To attain some quantitative measures, I set up a scale from zero to 0.5. Then I set up what I called a positive response index (PRI). The PRI for all of the faculty regarding their initial expectations of the students was 67 percent, which is fairly moderate. The next question dealt with the types of interactions the faculty had had with the students: "How would you describe [the interactions]? How often did you meet with the student? Were the interactions pleasant? What was your perception of the interactions?" The faculty had a PRI of 90 percent, which was quite high.

Perceptions of the students' ability to conduct research: "Was your student able to perform the research that was expected or that you had him or her engage in? Was he or she able to do it?" Again, a 90 PRI. Satisfaction with students' performance: "Were you satisfied with the student's performance?" The PRI was 88 percent, again quite high. Perception of the students' experiences: "Do you think that the student had positive experiences during the time he or she was here? How would you describe the experiences?" Based on interview results, there was a 90 PRI.

Perception of the students as prospective graduate students: "Based on what you've observed from your student this summer, how do you think he or she would perform as a graduate student at a major research institution (i.e., Research I)?" The PRI was 84 percent, again quite high. The overall PRI mean, excluding the initial expectation, was 88 percent. Thus, the overall perceptions of the faculty of the students were quite positive. These students, for the most part, had completed their junior year and were finishing their last year and hopefully would go to graduate school after they graduate.

Seventy-five percent of the faculty indicated that they had served as a mentor to graduate students. We asked whether they had had minority graduate students as protégés, and 67 percent indicated that they had. Additionally, 75 percent indicated that they had served as mentors to undergrads. We then asked the question, "Have you had minority undergraduate students for whom you served as a mentor?," and 57 percent indicated that they had. Forty-seven percent of preceptors reported that they had participated in the program in the past. When asked the question, "When you were an undergrad, did you have a mentor?," 57 percent said no, an interesting finding. To the question, "Did you have a mentor as a graduate student?" Fifty-three percent said that they had not. To the question, "Has the experience that you had as an SPGRE preceptor been worthwhile?," the PRI was 98 percent. When asked "Would you be willing to serve as a preceptor again?," the PRI was 95 percent.

There were 27 non-science preceptors who worked with 42 students. A number of the non-science faculty had more than one student with whom they worked. In the sciences, there were 24 preceptors who worked with 26 students. For the initial expectations of the science faculty, the PRI was 46 percent. An example of one science faculty member's response, which typified the perceptions of his colleagues was, "Well, I expected them to be able to do a few things but nothing major." The non-science preceptors had a different set of expectations, which were more positive. Perceptions of student-faculty interactions were pretty much the same—quite positive. The two groups of faculty's perception of the students' ability to conduct research was also fairly even. Perceptions of students as prospective graduate students: a PRI of 86 percent [non-science] versus 81 percent [science], again pretty much the same. Overall mean PRI: 91 percent [non-science] versus 85 percent [science].

A part that was of importance to me from an assessment standpoint were three categories to which the faculty members responded: (1) "Had a worthwhile experience as a preceptor"—the same PRI of 98 percent was observed for both non-science and science preceptors; (2) "Was the effort as an SPGRE preceptor worth it?"—a PRI of 100 percent [non-science] versus 94 percent [science]; and (3) "Would you be willing to serve as an SPGRE preceptor again in the future"—96 percent PRI [non-science] versus 94 percent PRI [science].

There were 39 white preceptors who worked with 45 students, and there were 11 black preceptors who worked with 21 students. Notably, all but one of the black preceptors were in non-science areas and they tended to work with more than one student. The initial PRI related to expectations of the students was 60 percent for the white preceptors versus 88 percent for the black preceptors, so the expectations of the black preceptors were considerably higher. The PRI related to interaction with students was essentially the same, 90 percent [white preceptors] versus 93 percent [black preceptors].

The PRI related to the perception of the students' ability to conduct research was again pretty much the same but again the PRI of the black preceptors was higher—95 percent compared to 89 percent. Related to satisfaction with the students' performance, white preceptors' PRI was 82 percent, which was again quite positive, but that of the black preceptors was considerably higher at 95 percent. Related to perception of the student's experience, the PRI was 91 percent for the white preceptors versus 88 percent for the black faculty.

Regarding their perceptions of their students as prospective graduate students at a major research university, the PRI was 83 percent for white preceptors versus 86 percent for black preceptors. The overall PRI mean was fairly close at 87 percent versus 91 percent for white and black faculty preceptors, respectively.

Again, looking at [preceptors'] background. Served as mentors to undergrad students: 91 percent of the black preceptors versus 72 percent of the white preceptors said they had. Most of the black preceptors had been mentors, so they had had that experience. Then the question of interest to me would be "Was the experience worthwhile?" Again, [the PRI] was very high, both white and black. "Was it worth it?": Again, quite high for both white and black. "Would you be willing to serve again?": Again, there was pretty much general agreement that they would do it.

I then looked at underrepresented groups [of faculty] and the underrepresented groups, of course, would be women and minorities. In this case "minority" meant African Americans; there were not really any other underrepresented ethnic groups participating as faculty [during] the two years studied. The initial expectation of women and minority preceptors was significantly higher than that of white male preceptors. Perceptions of interaction with students was high for both groups. Perceptions of the student's ability to conduct research was also high for both groups, but higher for women and minority preceptors.

Women and minority preceptors tended to be more satisfied with the students' performance. Perceptions of the students' experiences was high for both groups, but regarding the perception of students as prospective graduate students, there was a discernible difference between white male preceptors [79 percent PRI] compared to women and minority preceptors [89 percent PRI]. The overall mean PRI was 84 percent for white male preceptors compared to 92 percent for women and minority preceptors.

Now we look at how the two groups [white male preceptors and minority/ women preceptors] compared regarding experiences. Perceptions of whether or not the experience was worthwhile was quite high for both white male preceptors and women and minority preceptors. The PRI also was quite high for both groups regarding whether or not they perceived the effort to be worth it, and the PRI was also high regarding the faculty members' willingness to serve as preceptors again.

The overall responses are quite positive. To me this is a very encouraging set of results because of the willingness of faculty to participate, the perception of the students, the perception of the work, and the overall view of the program were quite encouraging. Now there is a problem because this program is one of about 75 that received major support from the Department of Education (ED) for women and minority participation in graduate studies. We initially received our funding finally in 1990 and about five years later the money disappeared because the ED program from which the funding emanated was terminated.

Both programs provided significant research experience for students. Moreover, the Department of Energy had funding that provided summer research for students, and the Environmental Protection Agency has funding that provided summer research for students; however, these sources of funding, for the most part, are gone. If you look at the National Research Council data for 1995, finally there had been a major increase in—or at least the number of African-American PhDs had finally surpassed—the number that was produced in 1976. That has occurred 20 years later!

My contention is that one of the influential factors in the increase of African-American doctoral recipients was the number of research programs that provided significant experiences for a considerable number of students who might not have really seriously considered doctoral studies. What the SPGRE Program and other programs have done for students is to provide them with the knowledge that, "Yes, I can be quite successful in graduate studies, and I can work quite well with faculty, and faculty have encouraged me and they respect me and so why not [pursue doctoral studies]."

"What the SPGRE Program and other programs have done for students is to provide them with the knowledge that, "Yes, I can be quite successful in graduate studies. . . ."

The upshot in the termination of significant funding sources is that in order to run a major research [mentoring] program, you would have to really scramble for funding. You can't rely on one or two sources. You have to piece things together and that of course, for someone who is trying to start something new, is virtually impossible. In reality, these programs have had a profound effect. If the responses of SPGRE faculty are any indication, the faculty are quite accepting of the programs, and they think [the programs] are great. Moreover, they think the students are fantastic, and they are looking forward to and participating as preceptors. ■

Educational and Career Experiences of African-American PhD Scientists

Dr. Willie Pearson, Jr.
Wake Forest University

My presentation is limited to a study that I conducted with partial support from the National Science Foundation. Let me take a moment to tell you something about the background of this study. Several years ago, I had a chance to meet and talk with a number of minority men who earned their PhDs in the 1930s and 1940s. I was struck by the fact that many attended the same graduate schools. These conversations represent the beginnings of my interest in the history of minorities in science.

Once being exposed to a chemistry course or chemistry experiment, respondents were more likely to have a definite discipline of science that they wanted to pursue.

This study focused exclusively on U.S. citizens who were African Americans and who finished high school in the U.S. A random sample was drawn from a list of 450 African-American PhD chemists. The sample comprised 47 persons, of which 44 were personally interviewed (a 94 percent response rate).

First, I will discuss some of the demographic characteristics of the sample. Respondents ranged in age from 31 to 86 years. Many of the older respondents were semi-retired or retired, but very active in science education related activities. The median age of the sample was 56 years, and the largest percentage of the respondents was in the 55 to 64 age group. A large proportion of the respondents resided in the South, followed by the North, East, and West.

Most of the respondents grew up in two-parent households. There were only a few who grew up in single parent households—usually due to divorce. One respondent grew up in a family with neither biological parent (i.e., raised by grandparents). Nearly two in five respondents were first-borns and/or only children. This finding is consistent with the literature on birth order of scientists. In terms of parental education, approximately two-fifths of both mothers and fathers were not high school graduates; however, fathers were considerably more likely to hold a college degree, academic doctorate, or professional degree. Ten of the respondents reported that their mothers were housewives. A small proportion of the respondents reported that their mothers did not work outside of the home. Of those who did work outside of the home, there was a range of occupations—from sharecropper to physician.

Slightly more than half of the respondents were married. In fact, half of the respondents were married while pursuing their doctorates. The median age at first marriage was 26 years, while the range was from 18 to 48. Nearly one in 10 chemists never married, and one-fifth were divorced and unmarried at the time of the interview. Slightly more than a 10th were remarried; approximately 7 percent were widowed.

Women were far more likely than men to have never married and if married were considerably more likely to have experienced a divorce. In contrast, men were more likely to have reported experience with the death of a spouse. The number of children ranged from zero to five; the typical family comprised two children. Generally, the first child was born when the respondent's median age was 31 years, while the range was 20 to 52 years. Overall, few respondents reported that a child had been born during a critical point in their careers.

Overall, respondents reported fond memories of their elementary and secondary school years. In particular, most singled out their math and science courses; usually their interest in mathematics emerged prior to their interest in science. This, of course, is due in large measure to earlier exposure to mathematics. By late middle school and early high school, most knew that they wanted a career in science. Once being exposed to a chemistry course or chemistry experiment, respondents were more likely to have a definite discipline of science that they wanted to pursue. Although a small minority reported that prior to high school they wanted to pursue a career in chemistry, the vast majority made this decision while in high school, usually around the junior year. Approximately a fourth made this decision after high school, usually in college, and there were only one or two persons who had made the decision to pursue a career in science or chemistry after college.

An overwhelming number of respondents graduated in the top quarter of their senior classes. Roughly one in 10 respondents graduated from private high schools, while the remainder earned diplomas from public high schools. Whether private or public, the vast majority of respondents graduated from high schools where they were in the racial majority. Although this was more typical in the South, the pattern was substantially no different in other parts of the country, particularly the North and the East. A majority of respondents reported that they had been encouraged by various persons to pursue studies beyond high school. Parents exerted the most influence on respondents' decisions to attend college. The next most influential person was likely to be a teacher.

A majority of the respondents entered college with intentions to major in chemistry, not always to pursue a career in chemistry. A substantial minority intended to pursue careers in medicine.

Historically black college and universities (HBCUs) produce more than their proportional share of African-American scientists, especially those earning PhDs. These results confirm those findings. However, there were some gender differences. Although six in 10 respondents had their baccalaureate origin in HBCUs, there were marked differences along gender lines. For example, males were more likely than females to earn their BS degrees at HBCUs. Overall, graduates of HBCUs expressed greater satisfaction with their undergraduate education than graduates of predominantly white colleges and universities (PWCUs), but there were a number of positive comments from those who finished PWCUs.

When asked who or what influenced their decisions to attend graduate school, the top response was "self." However, a close second was a "mentor."

For most respondents, the decision to attend graduate school was made while in college. When asked who or what influenced their decisions to attend graduate school, the top response was "self."

However, a close second was a "mentor." The age at receipt of a PhD ranged from 25 years to 39 years (the median age was 29 years). With respect to research specialties, the largest proportion of respondents concentrated in organic chemistry, followed by physical chemistry.

Few respondents reported the presence of African Americans on the faculty of their PhD-granting departments. No respondents in cohorts 1, 2, and 4 reported African Americans on their faculty. These data demonstrate the extent to which African Americans were underrepresented on the graduate chemistry faculties, particularly at PWCUs. In contrast, respondents were more likely to report the presence of African-American classmates at some point during their doctoral studies.

A substantial majority of respondents spent less than five years full time (enrolled time) to complete their doctorates. Few respondents completed their PhDs in less than three years or in more than six years. During the course of their doctoral studies, most respondents attended at least one meeting of a scientific society.

The "mentor" played a very strong role in the careers of the respondents.

In terms of geographic origins of PhD-granting institutions, most respondents earned their degrees in the North, followed by the East, the South, and the West. No respondents earned a doctorate from a Southern institution prior to 1965. A number of respondents earning their BS degrees in the South prior to 1965 stated that they were forbidden by law to pursue doctoral studies in predominantly white schools in their states because of racial segregation. They pointed to a practice of their states in providing financial assistance for them to pursue their doctoral studies outside of the state. A majority of the Southerners earned their doctorates in the North. The vast majority of respondents were very satisfied or satisfied with the quality of their doctoral education. For many, the level of satisfaction was tied to their relationships with "mentors" or "key faculty members."

Postdoctoral study became more prominent beginning with those who earned doctorates in Cohort II (1965 to 1974). Most respondents pursuing postdoctoral study were pursuing careers outside of HBCUs; those earning doctorates prior to the mid-1960s indicated that postdoctoral study was uncommon for their cohort. By the 1980s, however, it was common for respondents to pursue postdoctoral study, usually to specialize further and to produce more published research in order to become more competitive in the job market.

Prior to the late 1960s, HBCUs, and to a lesser extent government, were favorite sites for respondents to begin their careers. Respondents in predominantly white employment settings more often reported a feeling of isolation and a feeling of being under a microscope because they were the only African Americans in their units. Furthermore, most respondents reported direct experience with the glass ceiling. Nevertheless, a majority of academicians believed that the criteria for tenure and promotion were reasonably but often not specified in writing. All thought that criteria for tenure and promotion should be in writing. Academicians, regardless of institutional affiliation, reported difficulty in securing external funding sufficient to sustain their labs.

Post-1980 graduates of some of the nation's most prestigious PhD departments expressed considerable disappointment that they began their careers in settings similar to those of graduates of less prestigious PhD departments. Those who had attended some of the most selective undergraduate and graduate schools expressed a strong sense of disappointment because the prestige of their degrees did not overcome disadvantages associated with their racial status.

The "mentor" played a very strong role in the careers of the respondents. However, there are both positive and negative aspects of mentoring. Some respondents thought that their (white) "mentors" wanted to he helpful but were reluctant to be critical of minority students. As a consequence, many respondents thought that their writing and analytical skills were not critiqued strongly enough.

Regarding the distribution of Federal research funding, most subjects believed that merit was not primarily the determinant of success. Nearly all respondents believed that there is a need to expand the pool of African-American PhD chemists, regardless of employment trends. Also, most emphasized that all students should have more exposure to the contributions of African Americans to science and the importance of those contributions to society. A majority of respondents called for improvement in the quality of math and science education, especially in schools serving large numbers of low-income and minority students.

Women respondents reported experiences similar to those reported by other ethnic women. Several women respondents indicated that the chemistry community in general is male-dominated and sexist and that the most prominent, predominantly black chemistry organization is no different. A majority of the women indicated that they were not members of the so-called "invisible college," that is, the network of gatekeepers. Most women believed that they had to overcome barriers related to both race and gender. Some women reported that they were not taken seriously when presenting their research or asking questions at professional scientific meetings. One woman noted that the women in her department tended to have heavier teaching loads than the males and that male students (especially graduate students) did not take them seriously as they did male professors.

Most women believed that they had to overcome barriers related to both race and gender.

Finally, a majority of respondents employed in predominantly white settings, especially universities and industry, described personal experiences with racial discrimination and prejudicial attitudes. However, only a few reported being the object of overt racist comments by their colleagues and/or supervisors. Most respondents believed that while much progress has been made in reducing overt discrimination in the workplace, race still matters. One thing that was striking was that regardless of personal experiences, all loved chemistry and said that if they had it to do again, they would again choose chemistry. ■

1996 National Science Foundation Minority Postdoctoral Research Fellows and Mentors

Annual Meeting Agenda

September 11-13, 1996
Arlington, Virginia

WEDNESDAY, SEPTEMBER 11

1:00 - 1:10 p.m — **Welcome**

Dr. James H. Brown
Director, Division of Biological Infrastructure

1:10 - 5:15 p.m. — **Chalk Talks by Current Fellows**
(Chalk talks are five-minute presentations without visual aids)

Introductions of Fellows by:

Mr. William P. Butz
Director, Division of Social, Behavioral, and Economic Research

Dr. Thomas E. Brady
Director, Division of Environmental Biology

Dr. Bruce L. Umminger
Director, Division of Integrative Biology and Neuroscience

Dr. Julius H. Jackson
Director, Division of Molecular and Cellular Biosciences

5:30 p.m. — **Social Hour**

THURSDAY, SEPTEMBER 12

8:30 - 9:00 a.m. — **Opening Comments**

Dr. Cora B. Marrett
Assistant Director, Social, Behavioral, and Economic Sciences

Dr. Mary E. Clutter
Assistant Director, Biological Sciences

9:00 - 9:20 a.m. — **Diversity in the Scientific Workforce**

Dr. William A. Lester, Jr.
Senior Fellow, Office of the Director

9:20 - 10:30 a.m. — **Access to Mathematics and Science Careers for Underrepresented Minority Students: Research Findings and Explorations**

Dr. Beatriz Clewell
The Urban Institute

10:30 - 10:50 a.m.	**Break**
10:50 - 11:40 a.m.	**Production of Chicana and Chicano Doctoral Scientists: Status, Barriers, and Policy Recommendations** *Dr. Daniel Solorzano* University of California, Los Angeles
11:40 a.m. - 12:30 p.m.	**Perceptions of Faculty Research Preceptors Toward Minority Undergraduates in a Summer Research Program** *Dr. Henry Frierson, Jr.* University of North Carolina, Chapel Hill
12:30 - 2:00 p.m.	**Lunch**
2:00 - 2:30 p.m.	**Charge to Breakout Groups**
2:30 - 4:30 p.m.	**Breakout Group Discussions**
4:30 - 5:00 p.m.	**Group Report Writing**

FRIDAY, SEPTEMBER 13, 1996

8:00 - 9:00 a.m.	**Breakout Groups Work Session**
9:00 - 9:50 a.m.	**Educational and Career Experiences of African-American PhD Scientists** *Dr. Willie Pearson, Jr.* Wake Forest University
10:00 - 10:30 a.m.	**Comments from the Director** *Dr. Neal Lane* Director, National Science Foundation
10:30 a.m. - Noon	**Reports from Groups and Recommendations to NSF**
	Wrap-Up and Dismissal
1:00 - 1:30 p.m.	**Briefing Session for 1995 BIO Fellows**
	Optional Session on FAQs about Fellowships *Ms. Opal Fenwick, Ms. Carter Kimsey, and Ms. Bonney Sheahan*

National Science Foundation
1996 National Science Foundation Minority Postdoctoral Research Fellows and Mentors Annual Meeting Attendees

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