Written Testimony
Roundtable Series on the Science and Technology Workforce
House Science Committee
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Introduction

Thank you for inviting me here today to talk about the Nation's science and technology workforce on behalf of the National Science Board (NSB). I am George Langford, Professor of Biological Science at Dartmouth College and immediate past Chairman of the NSB Committee on Education and Human Resources and Vice Chairman of the Task Force on National Workforce Policies for Science and Engineering.

National Science Board Role in National Science and Engineering Policy

NSB has two statutory responsibilities: to establish policies for the National Science Foundation and to provide advice to the President and Congress on policy issues related to science and engineering. The Board's policy statements on the science and engineering workforce: "An Emerging and Critical Problem of the Science and Labor Force," (http://www.nsf.gov/sbe/srs/nsb0407/start.htm) accompanying the release of Science and Engineering Indicators 2004, and its more extensive study, *The Science and Engineering Workforce/Realizing America's Potential* (http://www.nsf.gov/nsb/documents/2003/nsb0369/nsb0369.pdf) fall under the second category, national policy advice, but also impact National Science Foundation policies.

Requirements for the Future S&E Workforce

You have asked that we focus on a number of questions for this discussion. I submit that the focal question that we should be asking is not: *Do we have a shortage or surplus of scientists and engineers?* The more critical question is: *What will it take for the US to maintain global leadership in discovery and innovation in a time of rising international competition in a global science and technology enterprise?*

Briefly, though science and engineering jobs in the US have grown faster than the overall workforce for a long time—and are expected to continue to do so (Figure 1, Mark's figure):

- US dependence on scientists born in other countries is increasing at all degree levels (Figure 2)
- Global competition for science and engineering talent is growing
- The US science and engineering workforce is aging. (Figure 3)
- There is a lack of growth in the number of bachelor's degrees in most fields of natural science and engineering fields earned by US citizens (Figure 4)
- Long term demographic trends show increasing shares of the college age population will be from groups that are underrepresented in natural sciences and engineering. (Figures 5)

A high quality, diverse and adequately sized workforce that draws on the talents of all US demographic groups and talented international students and professionals is crucial to our continued leadership and is therefore is a vital Federal responsibility. The Board has therefore concluded that it is a National Policy Imperative for the Federal Government to step forward to ensure the adequacy of the US science and engineering workforce. But the Federal government cannot act alone. All stakeholders must participate in initiating and mobilizing efforts that increase the number of US citizens pursuing science and engineering studies and careers.

Several troubling trends lead to this conclusion. Science and Engineering occupations have grown at a much higher rate than occupations in general over a long period of time. From 1980-2000 the annual growth rate was 4.9% for S&E occupations compared to 1.1% for all occupations. Even when you eliminate the high growth fields of math and computer science, the rate of growth in S&E occupations remains high—3.3%. (Figure 5). Replacement needs can be expected to accelerate and add to the need for scientists and engineers as the baby boom generation begins to retire. (Figure 6)

Though foreign born scientists and engineers have always been important participants in the US workforce, the growth of the foreign born share of our S&E workforce over the last decade is surprising. Foreign born S&E workers have greatly increased at all levels of education and training during the 1990s. By 2000, nearly two-fifths (38%) of the most highly trained (doctorate) workers were born abroad. For Engineering, the foreign born component of the doctoral workforce is over 50%. Given the increasing US dependence on foreign born workers, the drop in H-1B visas of nearly 50% between 2001 and 2002 is of concern. The percentage decline was even larger for science and technology workers. (Figure 7)

More recent data indicate that both refusal rates for high skill and student (F-1) visas are up and applications down. Exchange visitor (J-1) applications are up, but the total number issued are down due to the doubling of the refusal rate in that category.

National Policy for the S&E Workforce

A strategy for the Nation's S&E workforce that: (1) is highly reliant on the ready availability of international talent, (2) relies on a visa process responsive to the short-term needs of industry, and (3) is constrained by vital national defense and homeland security considerations will not serve this Nation well over the long term. Our Nation must give more attention to “growing our own” scientists and engineers to ensure the strength of our future workforce, and developing a better, more predictable process to continue to attract the best talent from other countries.

To implement its National Policy Imperative, the Board offers findings and recommendations in 5 areas:

1. Undergraduate Education in Science and Engineering
2. Advanced Education in Science and Engineering
3. Knowledge Base on the Science and Engineering Workforce
4. Precollege Teaching Workforce for Mathematics, Science, and Technology
5. US Engagement in the International Science and Engineering Workforce

<u>Undergraduate Education</u>

Undergraduate education in science and engineering is the most important level for increasing <u>US citizen</u> participation. BS holders form the largest component of the S&E workforce. In addition the BS pool is the source of US citizens who may continue on to <u>advanced</u> S&E degrees.

Looking at the BS degree level, the US has dropped from 3rd in global NS&E baccalaureate production to 15th from 1975 to 2000 (Figure 8). To even sustain our current low level of participation in comparison with other economies, we must increase participation by US citizens in engineering studies and careers. But demographic trends are not favorable.

Participation in science and engineering is uneven across demographic groups in our population (Figure 9). Our domestic college age population will stop growing after 2010. However, underrepresented minority groups will account for an increasing SHARE of the college age population, growing from 32 percent in 2000 to 38 percent in 2025. Hispanics will account for 90 percent of the increase in underrepresented minorities.

For ethnic groups, whites and Asians far exceed Hispanics, Blacks and Native Americans in their participation rates in NS&E fields—6 and 15 percent for whites and Asians, respectively, compared to 3 percent for underrepresented minorities. The difference in NS&E degree attainment between men and women is substantial—7.5 versus 4.6 percent. Though we have made some progress in participation of women and underrepresented minorities in S&E, we have a long way to go and a growing need for success.

A number of important factors contribute to low levels of US NS&E degree attainment. Low degree attainment occurs in spite of high interest among entering freshmen—25 to 30 percent of students intend to major in S&E fields on entering college, less than half of those earn a degree in those fields within 5 years. Entering freshman who are members of underrepresented minority groups show greater interest than whites in S&E degrees, but graduate at lower rates. For NS&E fields, degree programs are relatively costly for institutions to provide and curricula are inflexible for students. A growing share of college enrollments are nontraditional students—i.e., those that do not enter college immediately after high school and attend full time with family financial support. Nontraditional students are more likely to enroll in community colleges, which often cannot provide high quality science and mathematics curricula. Nontraditional students are also at a disadvantage in pursuing natural science and engineering degrees because of the inflexibility of curricula. The Board therefore concludes that the Federal Government must direct substantial new support to BOTH high ability students to enable them to attend full time and institutions to expand offerings for natural science and engineering students in order to improve attainment of NS&E degrees by American undergraduates from all demographic groups.

Advanced Education: Masters, PhD, and Postdoctoral levels.

The number of U.S. citizens and permanent residents enrolled in graduate programs in science and engineering fell during the late 1990s (Figure 10), while noncitizens continued to rise (Figure 11). A partial explanation of the falling citizen enrollment in graduate school has been that, in the US labor market, there are attractive career opportunities that do not require years of advanced science and engineering training. Increasing student interest after 2001 may reflect the decline of job opportunities requiring less education.

The percentage of non-citizens enrolled in advanced degree programs continued to rise from the mid 1990s to 2001. The Board has concluded that opportunity costs for high ability American students interested in pursuing advanced degrees in science or engineering were very high in comparison with some other alternative fields of study, and in comparison with opportunity costs for international students on temporary visas.

The Board therefore recommends that, to reduce opportunity costs for U.S. graduate students, Federal support for research and for graduate and postdoctoral education should respond to the real economic needs of students to cover such costs as health and other benefits that might otherwise be provided on a job. We are delighted to observe in the last set of statistics, for 2002, first time enrollment of American graduate students in S&E has increased substantially. Higher U.S. enrollments may reflect reduced "opportunity costs" for US citizens as a result of pressures to increase stipends and a less competitive job market. Additional evidence is found in data on National Science Foundation Fellowships data on its fellowship program. As shown in the table below, since stipends were increased there has been a marked drop in declines by awardees, from 12% in 2001-02 to 3.6% in 2004-05 and even lower in 2005-06 (although final figures are not in).

NSF Fellowship Awards

Fiscal Year	Stipend	Awarded	Declined	Rate
2001-02	$18,000	903	108	12.0%
2002-03	$21,500	903	106	11.7%
2003-04	$27,500	900	55	6.1%
2004-05	$30,000	1020	37	3.6%
2005-06	$30,000	1021	9	2.0% (11 still out)

In addition to more realistic financial support for students with outstanding abilities, the Board further has urged a wider range of educational options responsive to national skill needs be provided to advanced students. A few Federal programs to encourage cross sector and cross disciplinary experience for advanced students to align PhD and postdoctoral education with opportunities and needs in the workforce, especially outside of the academic sector. These include cross sectoral partnerships, such as NSF Engineering Research Centers and Science and Technology Centers programs that broaden exposure to multidisciplinary environments and EPA's STAR fellowship program that funds research by students pursuing advanced degrees in multidisciplinary environmental sciences.

Knowledge Base on the Science and Engineering Workforce

The Board recognizes not only the need to expand educational and training options but also for expanding knowledge of the entire S&E workforce system. Data and research are needed to provide an enhanced foundation for decisions--for education service providers, science policy, and individual career planning.

Existing data sources have a number of limitations for informing Federal policy and planning—like the lack of data on precollege science and math teachers the Board is now beginning to address.

The Board recommends that the Federal Government should lead a national effort to build a base of information in a number of specific areas, including:

- Status of the science and engineering workforce
- Science and engineering skill needs and utilization
- Strategies that attract high ability students and professionals to S&E careers.

Definitions of the Science and Engineering Workforce

The Board adopted a broad definition of the science and engineering workforce. From the perspective of a data system to serve policy needs it is important to consider all sources of S&E talent and the full range of occupations that use these talents. The S&E

workforce encompasses all levels of formal education including the community college system. The average natural scientist or engineer in the workforce has a baccalaureate (61%) and is employed by business/industry (73%).

Designated S&E occupations miss a lot of people with science and engineering degrees who use the skills attained through formal education in their jobs (Figure 12). There are many educated in science and engineering who move to other occupational categories—for example administration or teaching. In doing so, these workers are no longer identified as scientists or engineers by occupation. Yet their new positions may be absolutely vital in the S&E workforce and they may still use skills acquired through formal education and experience. We must also look at all sources of science and engineering talent, both domestic and foreign. The jobs requiring science and engineering skills need to be better captured in our data systems for policy and planning purposes.

Much better data are needed to support US policy on the international flow of S&E students and workers. This is an immediate and critical issue for US science and engineering, given our growing dependence on international students and professionals. The current reexamination of visa and immigration policies must recognize that engagement with the international science and engineering workforce is essential.

<u>The precollege teaching workforce</u>

With respect to areas where there is a shortage of scientists and engineers, the precollege teaching workforce is clearly one area in which well-recognized shortages exist. The problem of the precollege teaching workforce for mathematics, science and technology is foundational to our entire education system for the science and engineering workforce. The Board has offered a number of recommendations on recruitment and retention of well qualified precollege teachers in science, mathematics and technology and intends to expand its focus on undergraduate and precollege education in science, mathematics, engineering and technology (STEM) fields over the next few years.

Following up on its workforce policy study, the Board initiated additional activities to address concerns with long term S&T workforce trends. These include:

- A workshop on broadening participation in science and engineering, resulting in the Board's recommendations to NSF to promote a more diverse science and engineering faculty
- A workshop on engineering education this fall
- An NSB Commission on Education in Mathematics, Science and Technology, reconstituting the NSB Commission of 1982-83
- An assessment of *Science and Engineering Indicators* to increase utility to an expanded base of users
- A Companion Piece to the *Indicators 2006* on the subject K-12 education.

Conclusion

The Board has concluded that though the data indicate no immediate crisis, the long-term trends affecting the science and engineering workforce demand our attention. The Federal Government is uniquely qualified to coordinate activities at the national and global levels to benefit national workforce capabilities. It therefore has a primary responsibility to lead the Nation in developing and implementing a coordinated, effective response to our Nation's long-term needs for science and engineering skills.

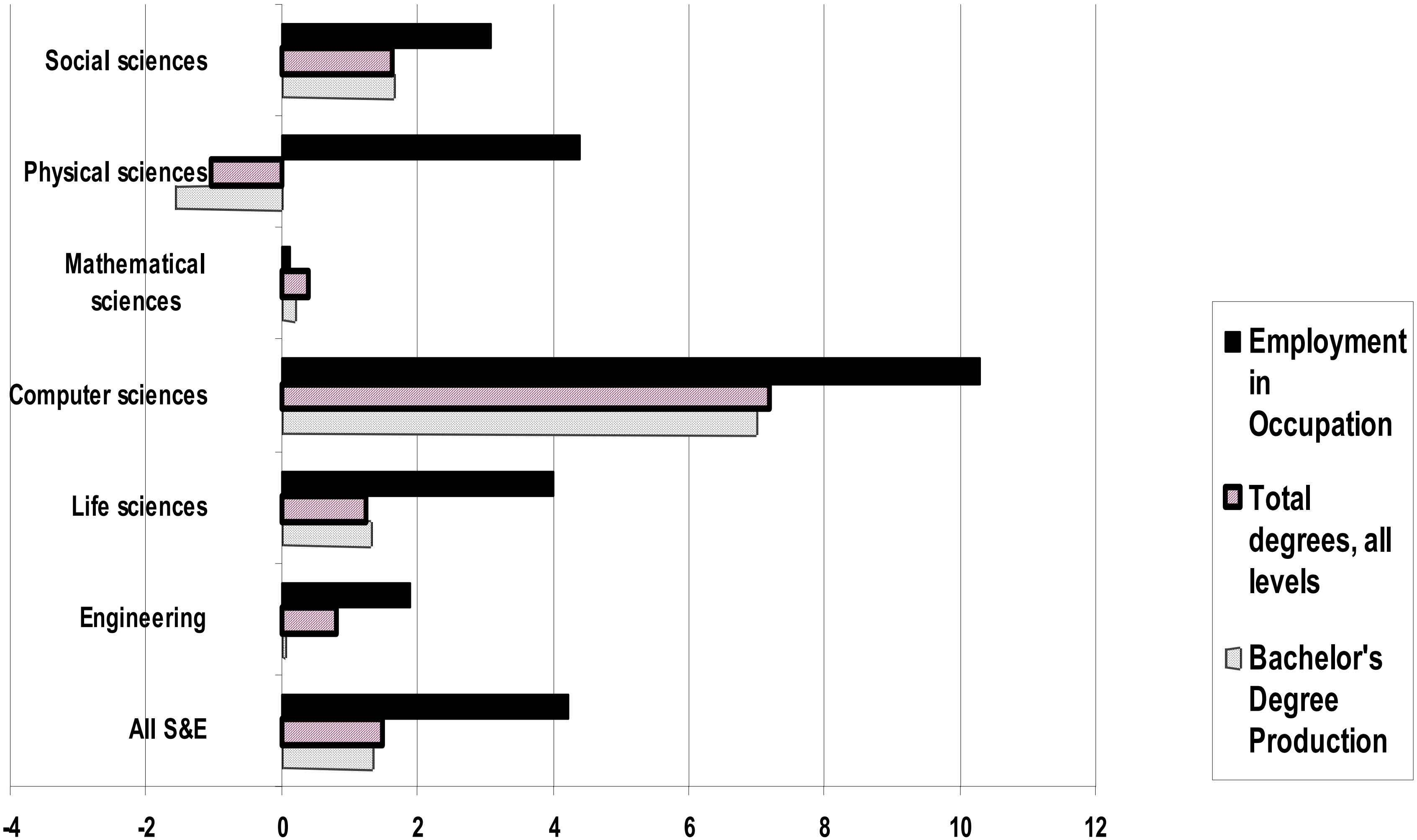
The focus question that we should be asking is: "What will it take for the US to maintain global leadership in discover and innovation in a time of increasing international competition in a global science and technology enterprise?"

To maintain our country's leadership for this enterprise it will be necessary to:

- Increase the participation of all U.S. citizens in science and engineering careers
- Continue to attract and welcome outstanding foreign-born students and professionals to pursue opportunities for S&E education and employment in the US.

US global leadership and future national prosperity and security depend on meeting this challenge.

Figure 1: Growth of Degrees and Jobs: 1980-2000 Average Annual Rates



Source: 1990 and 2000 Decennial Censuses, NSF/SRS data on degree production

Figure 2: Percent Foreign Born Among Individuals in Science and Engineering Occupations: 1990 and 2003

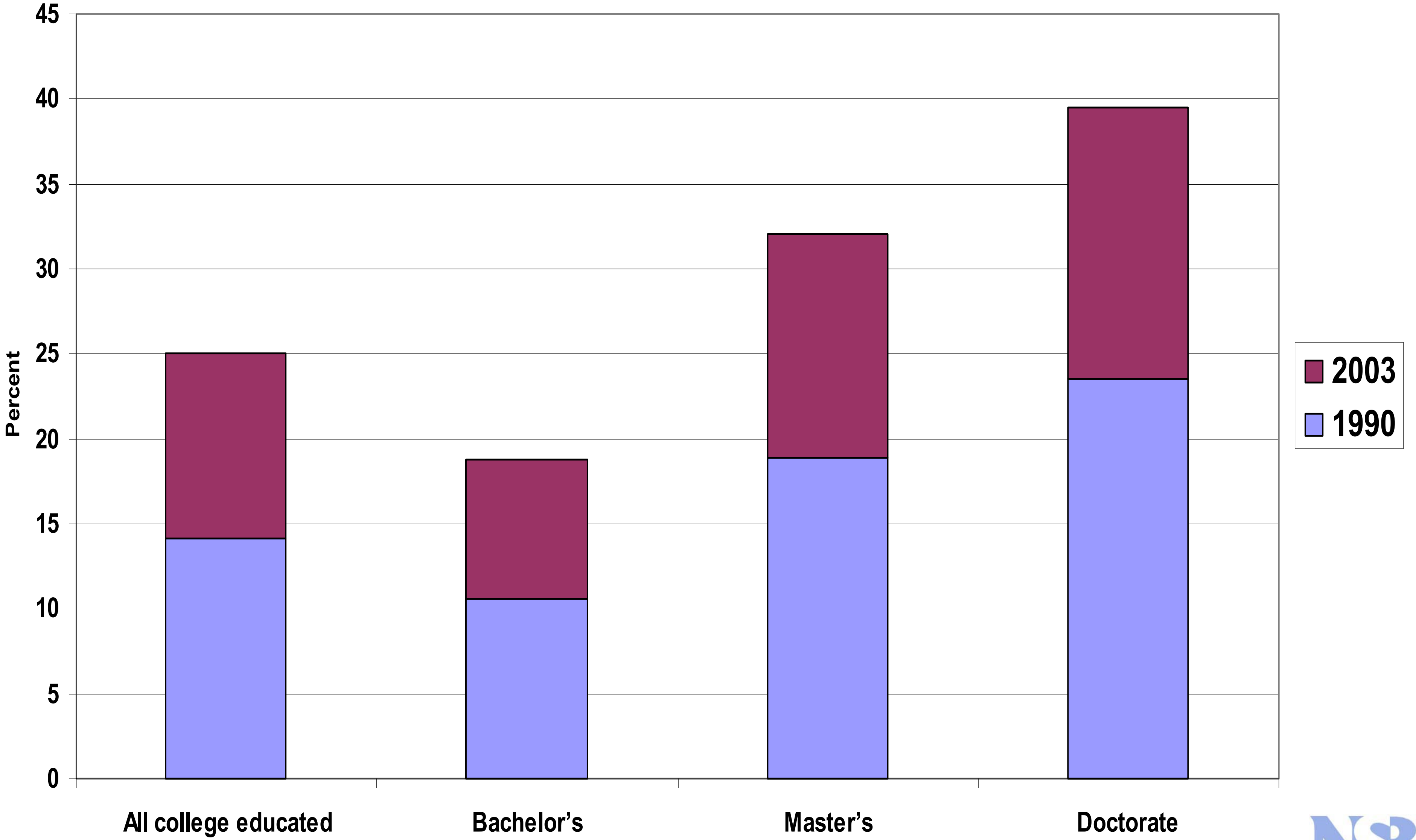
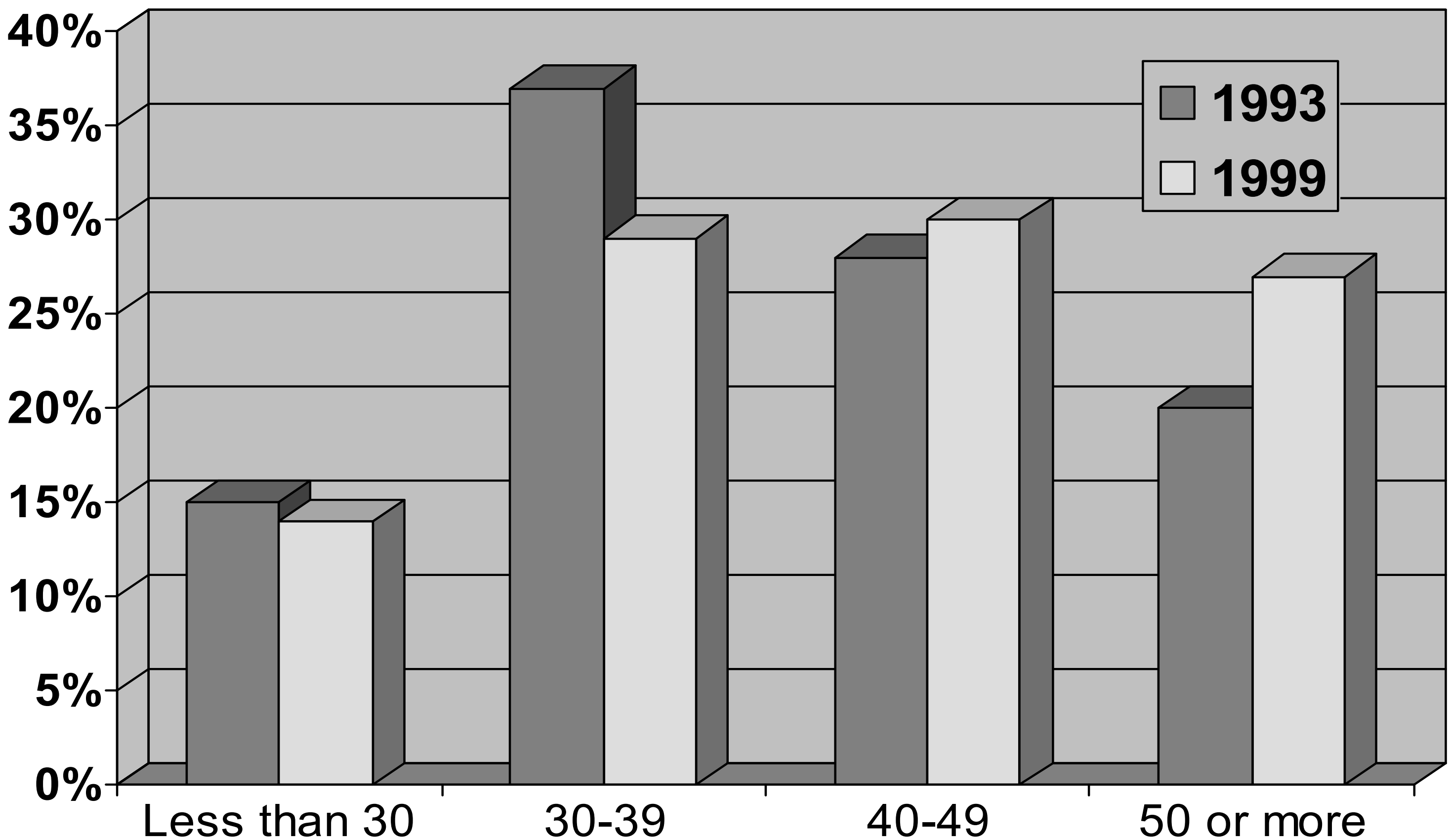
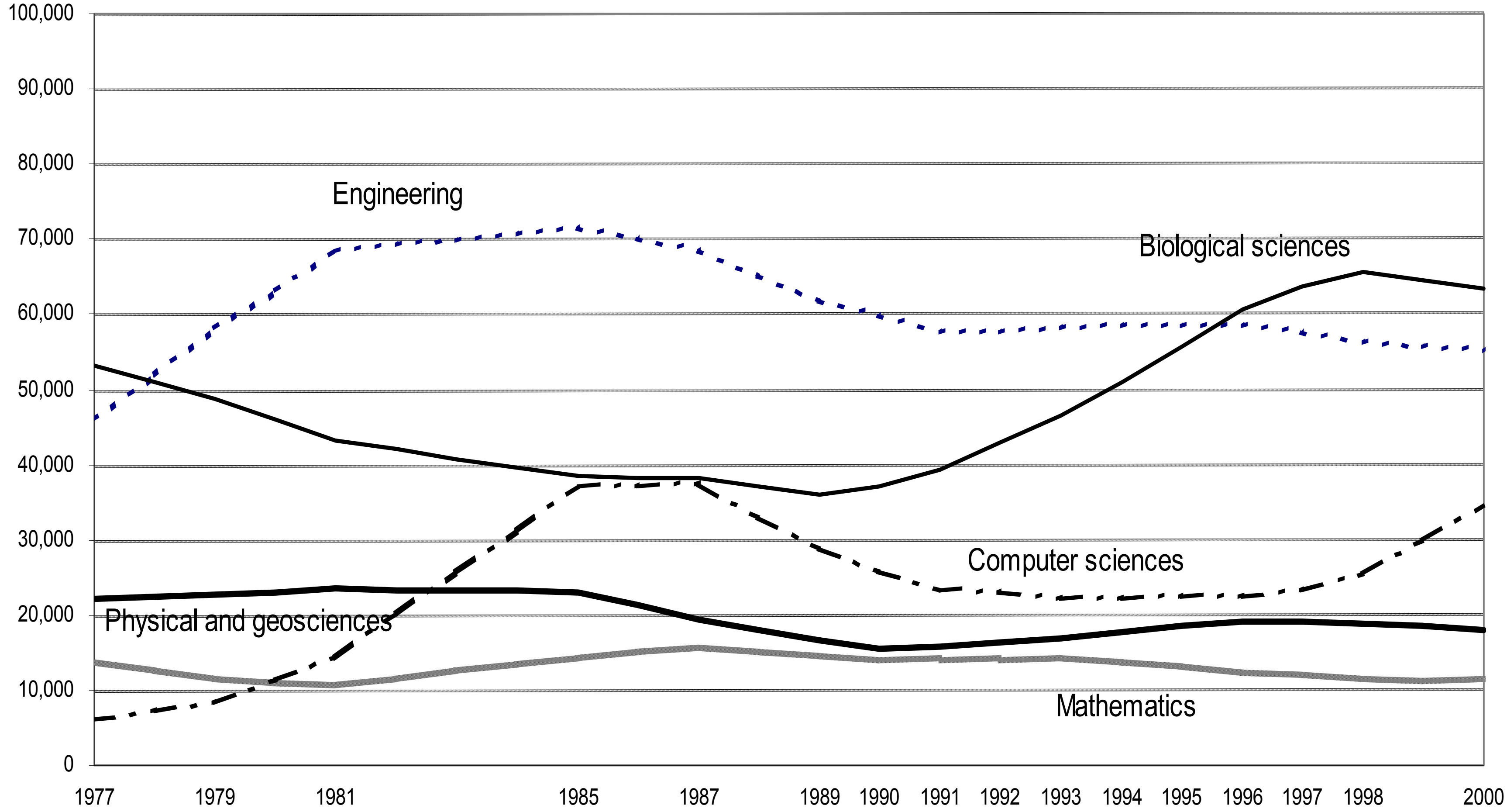


Figure 3: Science and Engineering Occupations' Labor Force Aged in the 1990s



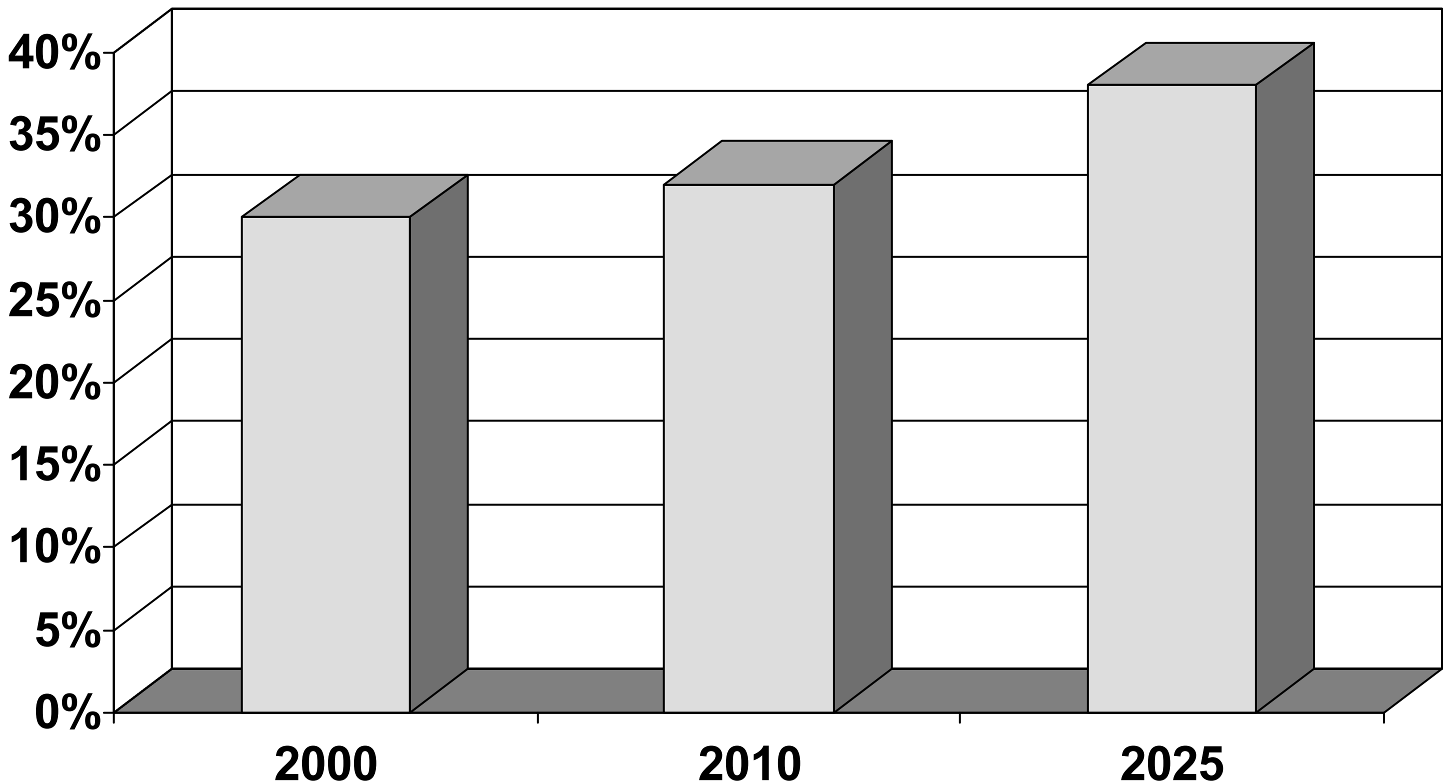
Source: ***Science and Engineering Indicators 2002*****, Appendix Tables 3-34 and 3-35, pages A3-102 and A3-108.**

Figure 4: Except for Biological Sciences, Natural Science and Engineering Bachelors Degrees To U.S. Citizens and Permanent Residents did not Increase or Declined since the mid 1980s



SOURCES: U.S. Department of Education, National Center for Education Statistics, Integrated Postsecondary Education Data System, Completions Surveys, unpublished tabulations (Washington, DC); and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov

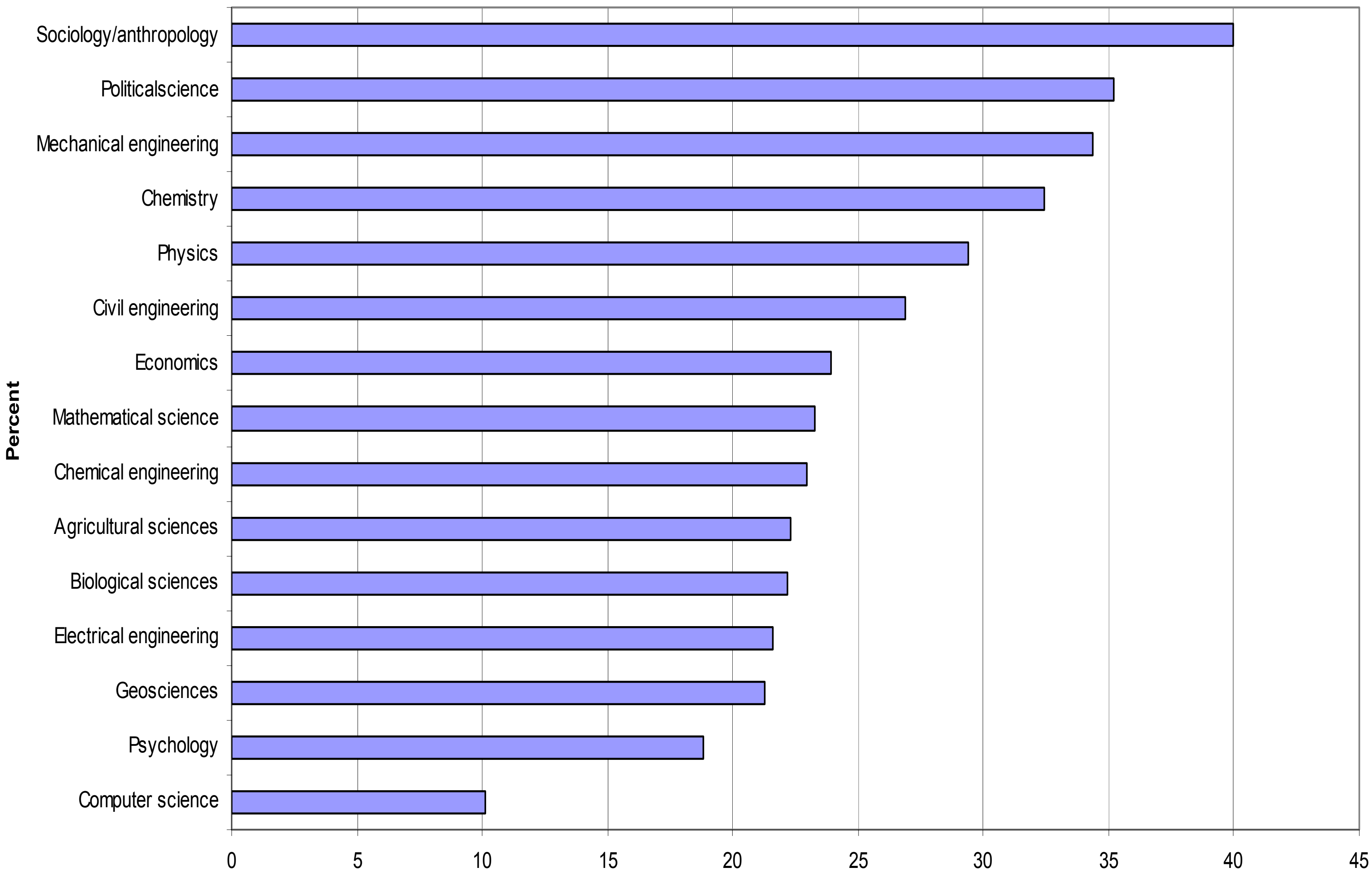
Figure 5: Groups Now Underrepresented in Science & Engineering will Account for an Increasing Share of the College-Age Population



Source: U.S. Bureau of the Census, Population Division, *Projections of theResident Population by Age, Sex, Race and Hispanic Origin: 1999 to 2100*

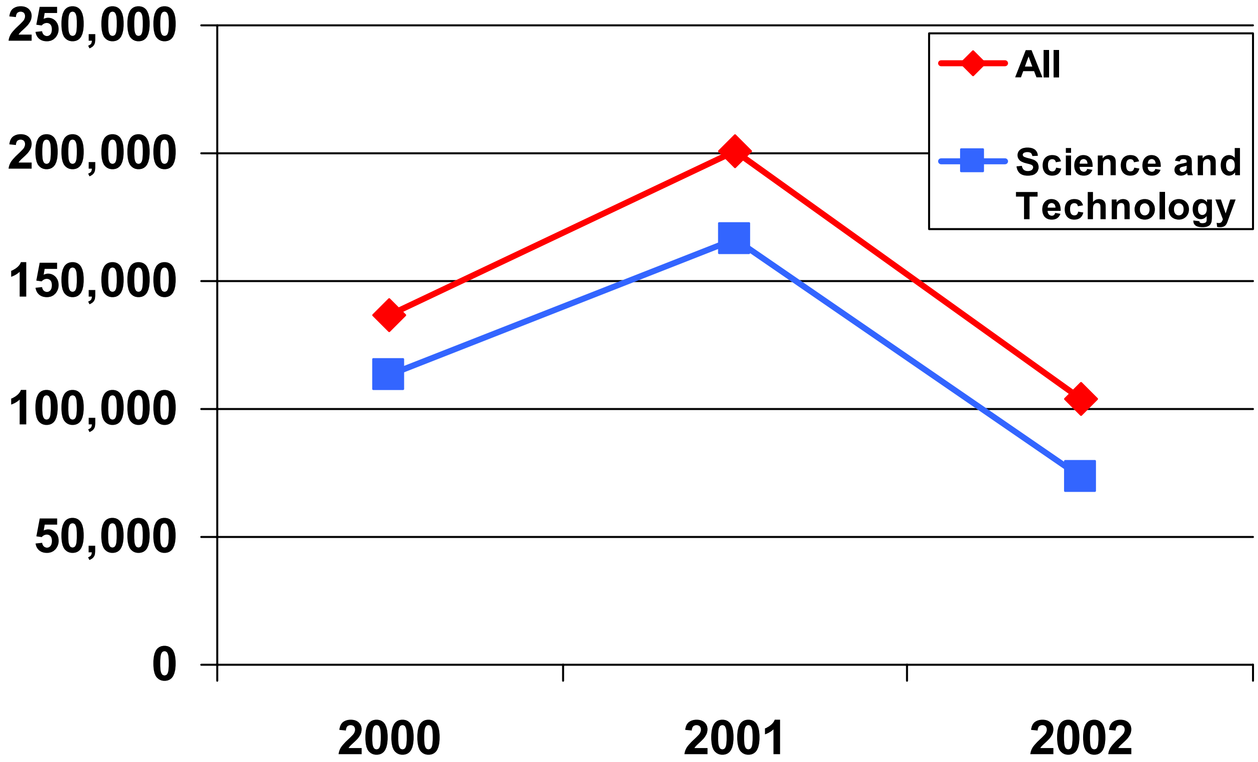
Note: Populations for 2010 and 2025 are projected.

Figure 6: Percent of Employed S&E Degree Holders Over Age 50: Selected Fields (1999)



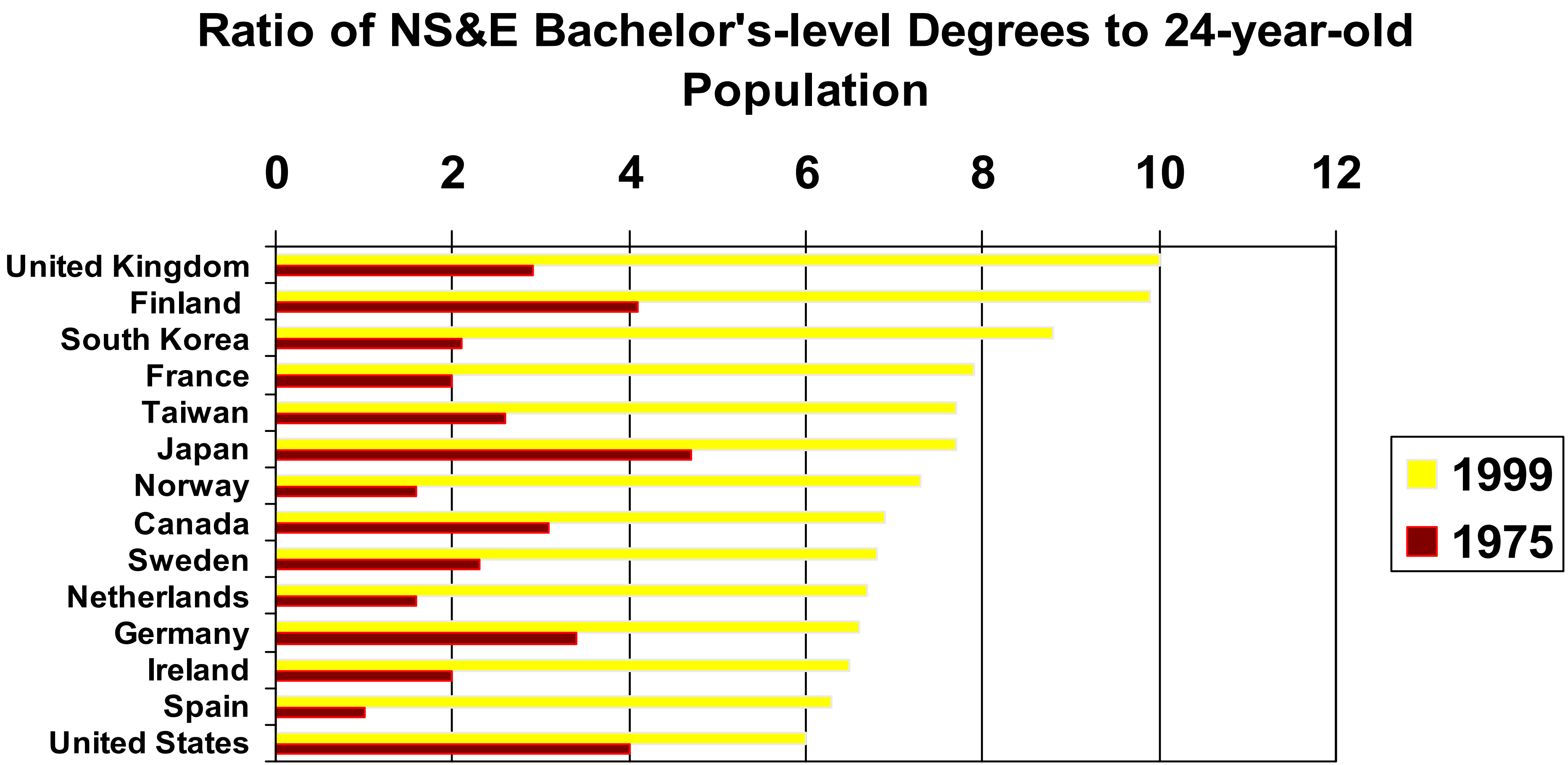
SOURCE: National Science Foundation/Division of Resource Studies (NSF/SRS), Scientists and Engineers Statistical Data System (SESTAT). 1999.

Figure 7: H-1B Visas Dropped Sharply in 2002



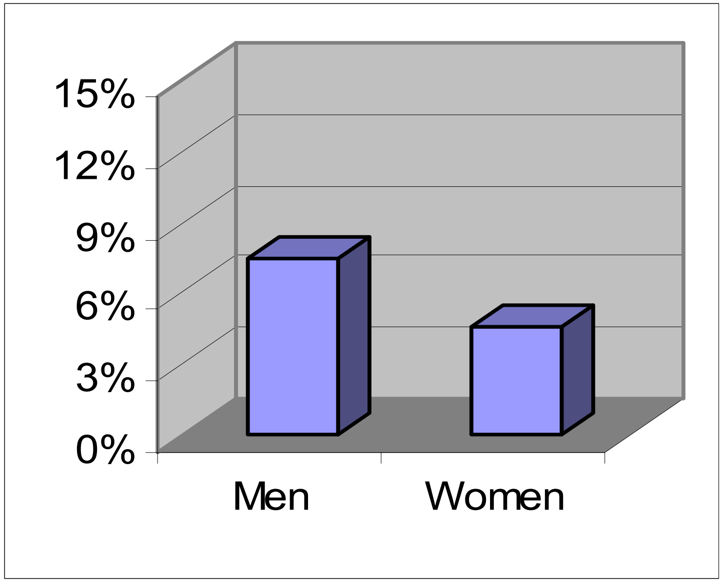
Source: Department of Homeland Security, Office of Immigration Statistics.

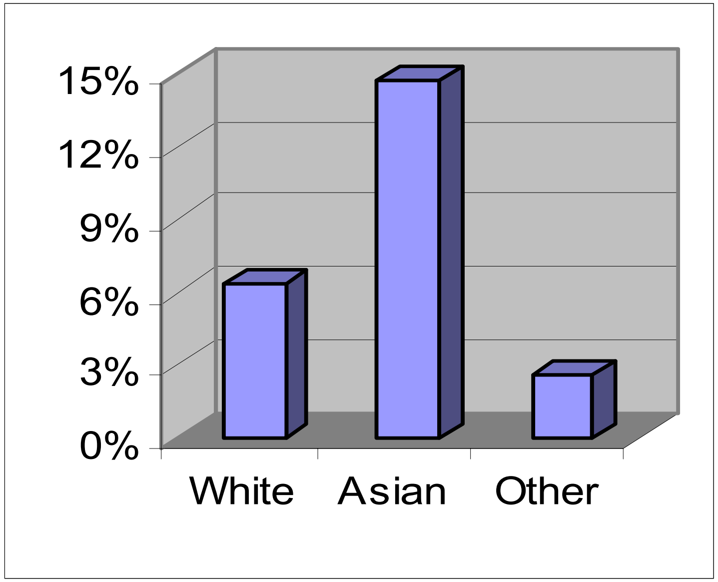
Figure 8: The US Rank in NS&E Bachelor's Level Degrees Dropped from 3rd to 14th in 15 Years



Source: SEI-2002, Appendix Table 2-18.

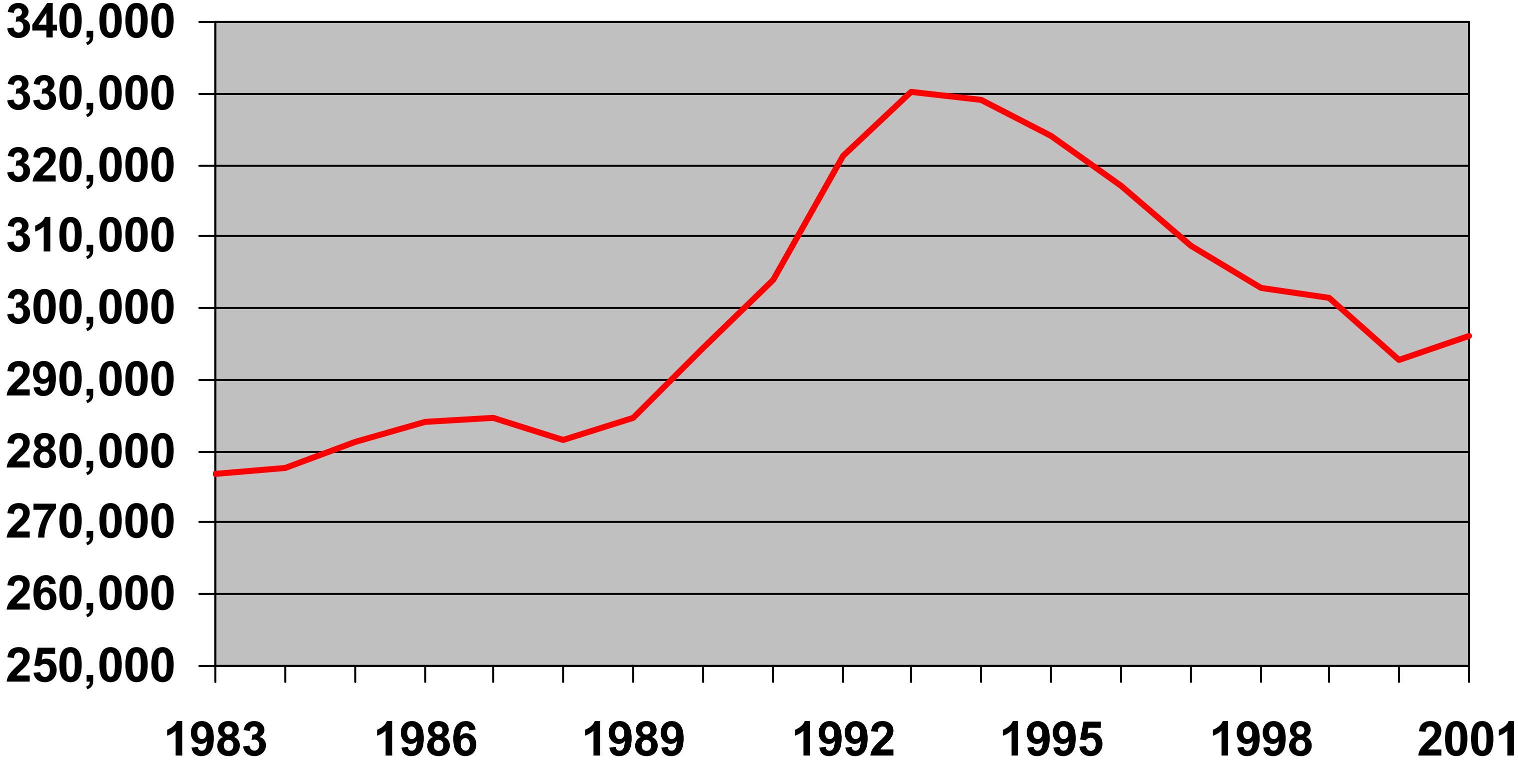
Figure 9: Women and Underrepresented Minorities Are Less Likely to Earn Bachelor's Degrees in Natural Science and Engineering





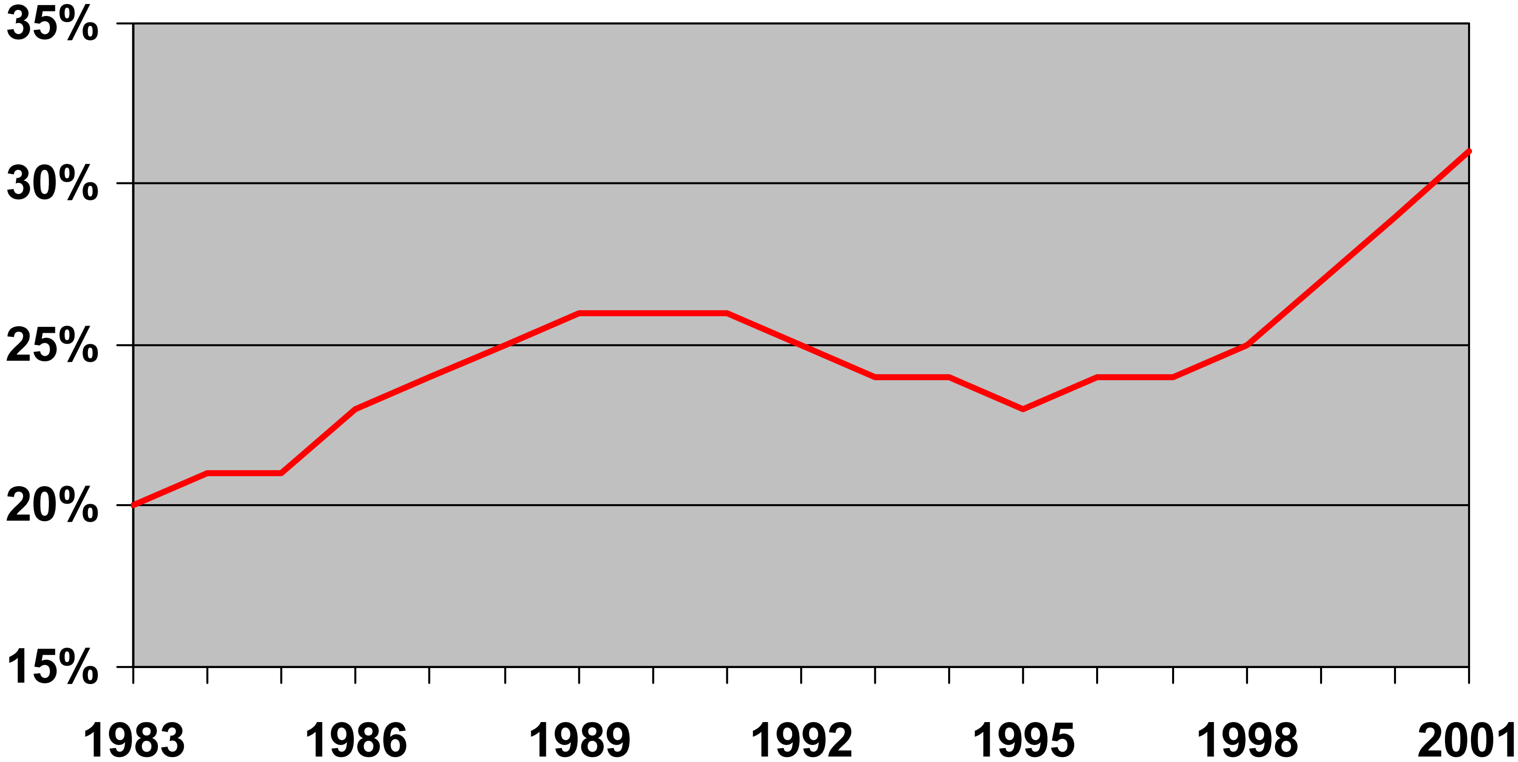
Source: ***Science and Engineering Indicators 2002,*** **Text Table 2-9, page 2-23.**

Figure 10: The Number of U.S. Citizens Enrolled in Graduate Study Fell During the Late 1990s



Source: Joan Burelli, "Graduate Enrollment Increases in Science and Engineering Fields, Especially in Engineering and Computer Sciences," NSF Issue Brief 03-315, April 2003, Table 1.

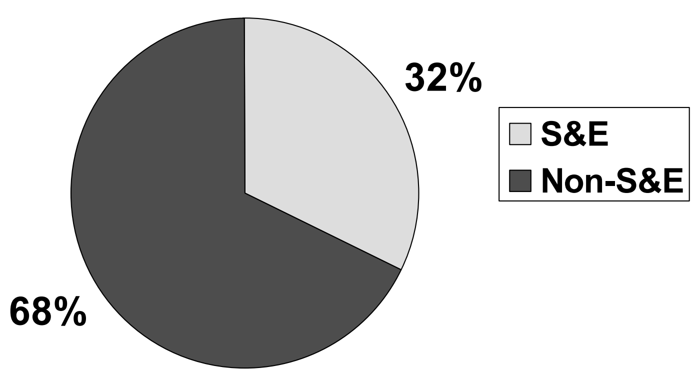
Figure 11: The Percentage of Graduate Students Who Are Not U.S. Citizens Continued to Rise



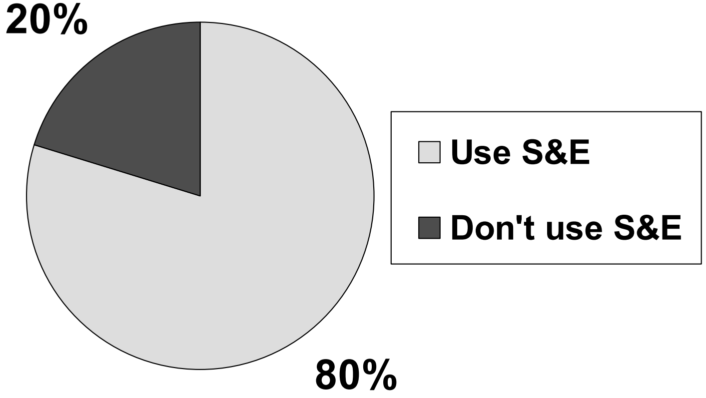
Source: Joan Burelli, "Graduate Enrollment Increases in Science and Engineering Fields, Especially in Engineering and Computer Sciences," NSF Issue Brief 03-315, April 2003, Table 1.

Figure 12: NSB Defines the Science and Engineering Workforce Broadly

Occupations of S&E Workers



Use of S&E Skills in Occupations



Source: *Science and Engineering Indicators 2002* Appendix Table 3-2, Page A3-5
Note: SESTAT definitions of "S&E" and "Non-S&E" occupations

Source: Calculated from *Science and Engineering Indicators 2002* Text Tables 3-1, 3-2, pages 3-6, 3-7.
Note: "Use S&E skills" includes all those in SESTAT-defined "S&E" jobs and those in SESTAT-defined "Non-S&E" jobs who "closely" or "somewhat" use S&E skills in those jobs

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Professor Langford received his Ph.D. degree in 1971 from the Illinois Institute of Technology, Chicago and his postdoctoral training at the University of Pennsylvania. Before joining the faculty at Dartmouth College, he was Professor of Physiology, School of Medicine, University of North Carolina at Chapel Hill. In 1991 he joined the faculty at Dartmouth as the first Ernest Everett Just Professor of Natural Sciences. He holds the positions of Professor of Biological Sciences, Dartmouth College and Adjunct Professor of Physiology, Dartmouth Medical School.

Professor Langford is a noted research scientist who studies the cytoskeleton in nerve cells of the brain. His research program will help to understand how the brain remembers, and what makes it forget when neurodegenerative diseases such as Alzheimer's take hold. For most of these studies, he uses the nervous system of the squid, a marine organism. Squid nerve fibers, called giant axons, are several times larger than a human's and offer unparalleled opportunities for observation and experimentation.

Professor Langford served on the National Science Board, the governing board of the National Science Foundation (NSF) from 1998-2004 and was Chair of the NSB Education and Human Resources Committee from 2002-2004 and was Vice-Chair NSB Task Force on National Workforce Policies for Science and Engineering 1999-2004. He currently serves on the following Boards: National Nanotechnology Infrastructure Network (NNIN), Burroughs Wellcome Fund Career Awards in the Biomedical Sciences Advisory Committee, NIH SYN Study Section, National Research Council Associateships Program Committee, Sherman Fairchild Foundation Scientific Advisory Board.

Professor Langford received the American Society for Cell Biology Ernest Everett Just Lectureship Award in1994, gave a Friday Evening Lecture at the Marine Biological Laboratory, Woods Hole, MA in 1994, and elected the Sigma Xi National Lecturer, 1991-1993. Professor Langford is an activist on important social issues. He works to influence local, regional and federal policies on the scientific workforce and the recruitment of under represented minority students to science and engineering.