Chapter 2
Higher Education in Science and Engineering

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Highlights

Structure of U.S. Higher Education

- **The U.S. higher education system provides broad access to varied institutions, which differ in size, type of administrative control (public or private), selectivity, and focus.** The system gives students flexibility in moving between institutions, transferring credits, entering and leaving schools, and switching between full- and part-time status.
- **Research and doctorate-granting universities produce most of the undergraduate engineering degrees (78 percent in 2000) and about half of the degrees in natural, agricultural, and social sciences.** However, master's and liberal arts institutions produce most of the undergraduate degrees in mathematics and computer sciences.
- **A higher percentage of baccalaureate recipients study science and engineering at research universities and selective liberal arts colleges than at other kinds of institutions.** Over the past 30 years, these S&E-focused institutions accounted for a declining percentage of higher education enrollments.
- **Historically black colleges and universities and Hispanic-serving institutions are important sources of S&E bachelor's degrees earned by minority students.** These institutions granted about one-third of all S&E baccalaureates awarded to blacks and Hispanics.
- **The fastest-growing major segment of higher education is community colleges.** These institutions are a bridge for students who want to attend 4-year colleges. Some S&E graduates earned credits at community colleges toward their degrees.
- **Universities and colleges are increasingly using advanced information technology and distance education; however, distance education remains limited in S&E fields.** Fewer than 10 percent of students in S&E fields took courses through distance education.

Enrollment in Higher Education

- **In the late 1990s, the U.S. college-age population reversed its 2-decade-long decline and began an upward trend.** After decreasing from 21.5 million in 1981 to 17.4 million in 1997, the college-age population reached 18.5 million by the 2000 census and is expected to increase to 21.7 million by 2015.
- **Increased enrollment will come from minority groups, principally Hispanics, a group traditionally underrepresented in S&E.** Between 1992 and 1998, overall enrollment increased by 1 percent, that of underrepresented minorities by 16 percent, and that of Asian/Pacific Islanders by 36 percent.
- **Interest in S&E study is high among freshmen, and their coursework preparation to study S&E appears as good as in the past.** However, 20 percent of those intending an S&E major reported needing remediation in mathematics, and 10 percent needed remediation in science.
- **A number of studies find that women and underrepresented minorities leave S&E programs at higher rates than men and white students, resulting in lower degree completion rates for women and underrepresented minorities.**
- **Enrollment in U.S. S&E graduate education peaked at 435,700 in 1993, declined through 1998, and rose to near its record level by 2001.** Graduate enrollment in engineering and computer sciences drove the recent growth, mostly because of foreign students. Enrollment in most other science fields remained level or declined.
- **Fluctuation in graduate S&E enrollment from 1994 to 2001 reflects a decline of 10 percent in enrollment by U.S. citizens and permanent residents, balanced by an increase of nearly 35 percent in foreign graduate S&E enrollment.** A 26 percent drop among white men and 9 percent drop among white women drove the U.S. decline. U.S. minority enrollment increased by 22–35 percent. Foreign enrollment declined from 1992 to 1996, returned to its former level by 1999, and reached an all-time high in 2001.
- **One in five S&E graduate students received primary support from the Federal Government in 2001.** The support was mostly in the form of research assistantships (RAs)—67 percent, up from 55 percent 2 decades earlier—and was offset by declining traineeships. For students supported through non-Federal sources, teaching assistantships were the most prominent mechanism (40 percent), followed by RAs (32 percent).
- **For doctoral students, notable differences exist in primary support mechanisms by sex, race/ethnicity, and citizenship.** Men are most likely to be supported by RAs (38 percent), whereas women are most likely to support themselves from personal sources of funds (34 percent). Whites and Asian/Pacific Islanders are most likely to derive primary support from RAs (26 and 31 percent, respectively), whereas underrepresented minorities depend more on fellowships (36 percent). The primary source of support for foreign doctoral students is an RA (43 percent).

Higher Education Degrees

- **The ratio of bachelor's degrees in natural, agricultural, and computer sciences; mathematics; and engineering (NS&E) to the population cohort stood between 4 and 5 per 100 for several decades but increased to 5.7 in the late 1990s,** largely on the strength of increases in the number of computer science baccalaureates.

- **The annual output of S&E bachelor's degrees rose steadily from 303,800 in the mid-1970s to 398,600 in 2000.** They represented approximately one-third of all baccalaureates for the period. These consistent trends mask considerable variations among fields.
- **Over the past quarter-century, women and members of minority groups earned greater proportions of S&E bachelor's degrees, as the percentage of degrees earned by white students declined from 87 to 68 percent.** By 2000, women earned half the degrees, up from one-third. Degrees awarded to underrepresented minorities rose from 9 to 16 percent, and those awarded to Asian/Pacific Islanders increased from 2 to 9 percent.
- **Despite the considerable progress of underrepresented minorities in earning bachelor's degrees between 1990 and 2000, the gap in educational attainment between these groups and whites remains wide, especially in S&E fields.** In 2000, underrepresented minority groups earned 17.9 percent of any type of college degree per 100 24-year-olds, about half the ratio earned by whites. The gap between these minorities and whites is even larger for NS&E degrees.
- **Increasing numbers of S&E doctoral degree recipients are women, minorities, or foreign; the share of U.S. whites decreased from 71 percent in 1977 to 50 percent in 2001.** The share of doctorates awarded to U.S. citizens declined from 77 to 59 percent.
- **Noncitizens accounted for most of the growth in U.S. S&E doctorates from the late 1980s through 2001.** Their annual growth rate for earning degrees during this period was 3 percent, approximately three times that for U.S. citizens.

Foreign Doctoral Degree Recipients

- **From 1985 to 2001, students from China, Taiwan, India, and South Korea earned more than half of the 148,000 U.S. S&E doctoral degrees awarded to foreign students, which is four times the number awarded to students from Europe.**
- **Nearly 30 percent of the actively employed S&E doctorate holders in the United States are foreign born, as are many postdocs.** Most foreign-born doctorate holders working in the United States obtained their degrees in the United States.
- **Foreign students earning U.S. S&E doctorates are increasingly planning to stay in the United States after degree receipt.** In the period 1998–2001, 76 percent of foreign doctoral degree recipients in S&E fields planned to stay in the United States, and 54 percent had firm offers to do so.
- **Stay rates vary by place of origin, with many Chinese and Indian students staying and most South Korean and Taiwanese doctoral degree recipients leaving after degree receipt.** Stay rates of graduates from France, Italy, and Germany have increased well above their long-term average; stay rates of Eastern European doctoral degree recipients are exceeded only by those of Indian doctoral degree recipients.

International S&E Higher Education

- **In the 1980s and 1990s, the college-age cohort decreased in all major industrialized countries, although at different times, with different durations, and to varying degrees.** To produce enough S&E graduates for increasingly knowledge-intensive societies, industrialized countries have encouraged a higher proportion of their citizens to obtain a higher education, have trained a higher proportion in S&E, and have recruited S&E students from other countries, especially from the developing world.
- **Although the United States has historically been a world leader in providing broad access to higher education, many other countries now provide comparable access.** The U.S. ratio of bachelor's degrees earned to the college-age population remains high (33.8 per 100 in 2000). However, nine other countries now provide a college education to approximately one-third or more of their college-age population, and others are expanding access.
- **The proportion of the college-age population earning NS&E degrees is substantially higher in more than 16 locations in Asia and Europe than in the United States.** In the United States, the ratio has gradually increased from between 4 and 5 to 5.7 per 100 over 3 decades. South Korea and Taiwan increased their ratios from 2 per 100 in 1975 to 11 per 100 in 2000–01, and several European countries have doubled and tripled their ratios, reaching figures between 8 and 11 per 100.
- **The 1990s witnessed a worldwide increase in the number of students going abroad for higher education study to the well-established universities in the United States, United Kingdom, and France, with the largest increases at the graduate level in S&E fields.** However, universities in other countries, including Japan, Canada, and Germany, also expanded their enrollment of foreign S&E graduate students.
- **The proportion of doctoral S&E degrees earned by foreign students, particularly in engineering, mathematics, and computer sciences, is increasing in the major host countries.** In 2001, noncitizens earned 56 percent of the doctoral engineering degrees awarded in the United States, 51 percent in the United Kingdom, and 22 percent in France. They earned 49 percent of the mathematics and computer science doctorates awarded in the United States, 44 percent in the United Kingdom, and 29 percent in France.

Introduction

Chapter Overview

Modern societies are committed to fostering economic growth through scientific and technological innovations developed by an educated workforce trained in institutions of higher education. In the United States and around the world, such institutions have expanded to enroll and graduate increasing numbers of students in science and engineering at all levels.

Scientific, technological, and demographic changes are altering the face of higher education. As science changes to become more interdisciplinary and mathematical, higher education must adapt to demands for new skills. Information technology (IT) facilitates new, more flexible modes of delivering higher education and, by making scientific data more readily accessible to students, opens new possibilities for learning. Demographically, college-age cohorts have grown smaller in the major industrialized countries. Young, native-born males, typically a prime source of S&E graduates, are a smaller proportion of the college population. In the United States, higher education increasingly serves women and minorities—groups that are historically underrepresented—and older students, among S&E graduates. Colleges and universities confront the challenge of training students from these hitherto underrepresented groups.

Foreign students are playing an increasing role in higher education throughout the industrialized world. U.S. higher education has benefited from an influx of foreign S&E enrollees, who play a large role in graduate education and as research and teaching assistants on U.S. campuses. Many of them remain in the United States and become part of the workforce. Whether more stringent security measures in the wake of the events of September 11, 2001, will affect the role of foreign students is yet unknown.

Chapter Organization

This chapter describes some characteristics of the U.S. institutions that deliver higher education, paying special attention to new and emerging practices and institutional forms. It then profiles the students who enroll in higher education and receive degrees, especially in S&E, disaggregating the data by sex, field of study, race/ethnicity, and citizenship at the various levels of education. Because doctoral-level scientists and engineers are so important to science and technology (S&T) innovation and competitiveness, a section is devoted to the flow of doctoral students to the United States and back to their countries of origin. The chapter closes by considering patterns and trends in degree production in other countries, especially those that are advanced and rapidly advancing.

Structure of U.S. Higher Education

The U.S. higher education system provides broad access to varied institutions, which differ in size, type of administrative control (public or private), selectivity, and focus. (See sidebar, "Carnegie Classification of Academic Institutions.") The system gives students flexibility in moving between institutions, transferring credits, entering and leaving schools, and switching between full- and part-time status.

Nonprofit degree-granting institutions that offer face-to-face classroom education continue to dominate U.S. higher education. These traditional institutions have incorporated new modes of education delivery, through IT and distance education, into their repertoires. New institutional forms that feature control by profit-making firms, certificate programs designed to enhance specific skills, and primary reliance on distance education, alone or in combination, have also

Carnegie Classification of Academic Institutions

Research I and II universities offer a full range of baccalaureate programs and graduate education through the doctorate level, award 50 or more doctoral degrees a year, and receive at least $15.5 million in Federal research support annually.

Doctorate-granting I and II institutions offer a full range of baccalaureate programs and graduate education through the doctorate level but in a narrower range than the research universities. They award at least 20 doctoral degrees in at least three disciplines; no Federal research fund limit is required.

Master's (comprehensive I and II) institutions offer a broad range of baccalaureate programs and, generally, graduate education through the master's degree. The latter often focuses on occupational or professional disciplines such as engineering or business administration. Minimum enrollment is 1,500 students.

Baccalaureate (liberal arts I and II) colleges are mostly 4-year institutions focused on awarding a bachelor's degree. A few highly selective colleges award more than 40 percent of their baccalaureates in liberal arts and science fields.

Associate of arts (2-year) colleges offer certificate or degree programs through the associate's degree level and, with few exceptions, offer no bachelor's degrees.

Professional and other specialized schools offer various degrees, including doctorates, but they specialize in religious training; medicine and health; law; engineering and technology; business and management; art, music, and design; and education. The category also includes corporate-sponsored institutions.

emerged in recent years. However, these new forms still play a limited role in S&E education.

Institutions Providing S&E Education

The U.S. higher education system consists of approximately 3,700 degree-granting colleges and universities that served about 15.6 million students and awarded 2.3 million degrees in 2000. Almost one-quarter of the degrees were in S&E fields (appendix tables 2-1, 2-2, 2-3, and 2-20).

Figure 2-1 shows the distribution of institutions, enrollment, degrees, and research and development expenditures across the different types of academic institutions. The institutions are classified according to a typology published by the Carnegie Foundation for the Advancement of Teaching 1994.[1] The typology groups institutions on the basis of the type and breadth of their programs, the volume of doctoral degrees conferred, the amount of Federal R&D funding, and their selectivity in the early 1990s.

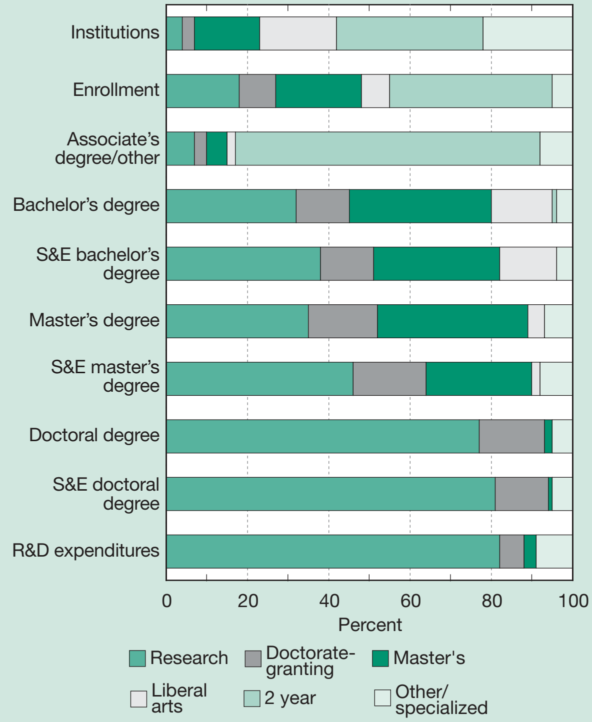
Although research and doctorate-granting universities award most of the S&E baccalaureates, students earn such degrees at all kinds of institutions. In different S&E fields, the role of different kinds of institutions varies. Research and doctorate-granting universities produced most of the undergraduate engineering degrees (78 percent in 2000) and about half of the degrees in natural and agricultural sciences and in social and behavioral sciences. However, master's and liberal arts institutions produce most of the undergraduate degrees in mathematics and computer sciences (figure 2-2).

A higher percentage of baccalaureate recipients studied S&E at research universities and selective liberal arts colleges than at other kinds of institutions. However, over the past 30 years, these S&E-focused institutions accounted for a declining percentage of higher education enrollment (appendix table 2-2). Master's and doctoral degrees were concentrated in research and doctorate-granting universities (appendix table 2-3).

The fastest-growing major segment of higher education is community colleges. These institutions are a bridge for students who want to attend 4-year colleges, and some S&E graduates earn credit at community colleges toward their degrees (Bailey and Averianova 1999). Community colleges also offer remedial courses and services and enroll millions of students in noncredit and workforce training classes. Enrollment in remedial courses often includes many older adults taking refresher courses (American Association of Community Colleges 2001).

Some traditional colleges and universities educate a disproportionate share of undergraduate racial/ethnic minorities, including historically black colleges and universities (HBCUs), Hispanic-serving institutions (HSIs), tribal colleges and universities (TCUs), and postsecondary minority institutions. In 1998, 29 percent of the blacks who received S&E bachelor's degrees earned them at HBCUs. About one-third of Hispanics who earned S&E bachelor's degrees did so at HSIs. Only six TCUs are 4-year colleges or universities; the rest are 2-year schools. Of the six TCUs that offer bachelor's degrees, two offer baccalaureates in S&E fields (NSF/SRS 2003c).[2]

Figure 2-1
Distribution of selected aspects of U.S. higher education, by Carnegie type of institution: 2000



NOTE: Other includes first professional degrees and all types of graduate and undergraduate certificates.

SOURCES: U.S. Department of Education, Enrollment and Completion surveys; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix tables 2-1, 2-2, and 2-3.

Science & Engineering Indicators – 2004

New Modes of Instructional Delivery

Institutions of higher education are increasingly using advanced IT and distance education and are exploring the best ways to use these recent innovations to improve S&E education.

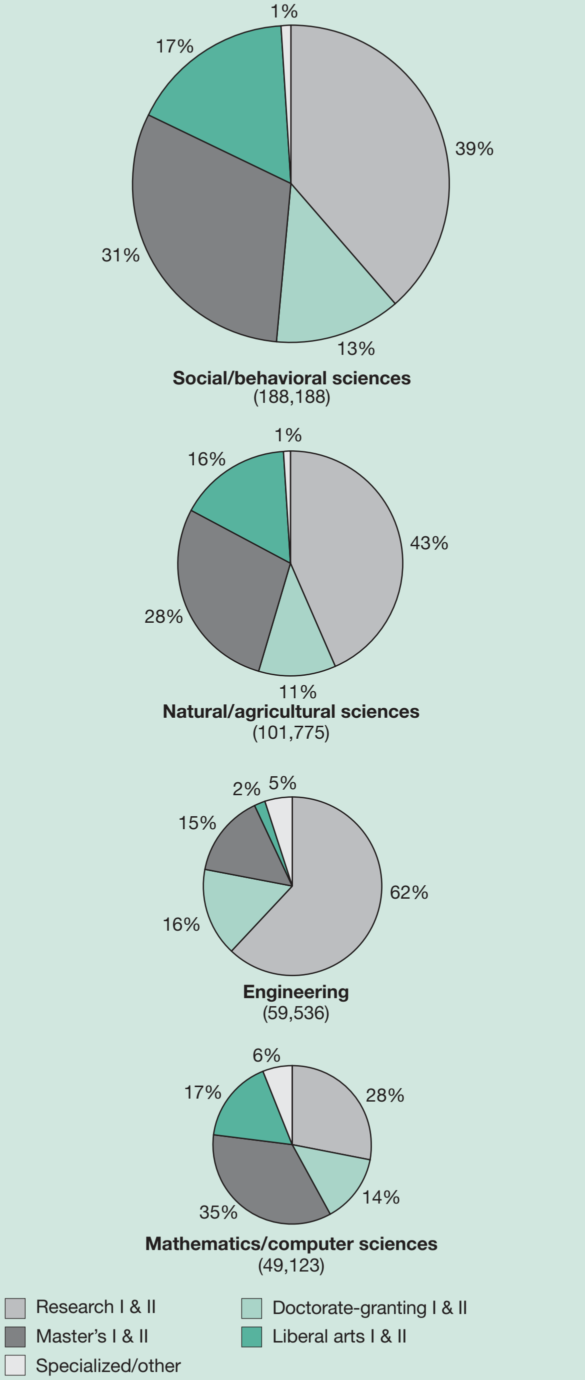
IT in Traditional Institutions

Advances in IT have provided scientists with powerful tools to amass and manipulate large databases and to solve previously intractable problems requiring complex calculations. Computer laboratories can bring advanced research to undergraduates via simulations. (See sidebar, "IT in Forest Ecology.") U.S. institutions of higher education are developing

[1]The 2000 Carnegie Classification is under review, and a series of distinct classification schemes is expected to be introduced in 2005. http://www.carnegiefoundation.org/Classification/future.htm.

[2]The U.S. Department of Education, Office of Civil Rights, has definitions and a list of minority-serving institutions at http://www.ed.gov/offices/OCR/minorityinst.html.

Figure 2-2
S&E bachelor's degrees, by field and institution type: 2000



NOTES: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences. Two-year institutions award a few S&E bachelor's degrees, included in totals by field. Number of degrees in parentheses.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-3.

Science & Engineering Indicators – 2004

IT in Forest Ecology

Hampshire College (Amherst, MA) designed two computer programs, SimForest B and G, that enable users to simulate forest growth and composition over extended periods under various conditions controlled by the user. SimForest B simulates tree and forest growth, the succession of species over time, and the effects of environmental and man-made disturbances over time. The students set environmental parameters such as rainfall, temperature, soil fertility, soil texture, and soil depth. They plant a plot of trees from a list of more than 30 species and then run the simulation and observe the trees as they grow and the forest evolves. SimForest G lets students and faculty explore and manipulate the program that drives SimForest B, thus affording students a greater opportunity to explore modeling as a tool for understanding complex environments. Such simulations of long-term ecological effects enable students to run experiments that encompass the randomness, complexity, and emergent phenomena observed in nature. The material is available on the Hampshire College site at http://ddc.hampshire.edu/simforest.

the IT infrastructure needed for computer-driven classes. In 2002, more than half of the classes in colleges used Internet-based resources, about one-third had Web-based pages for courses, and rates of e-mail use in all college classes were close to 70 percent. In addition, campuses are investing in wireless networks. Nearly 70 percent of the campuses responding to the 2002 Campus Computing Survey indicated that wireless networks were functioning in at least some part of their campus (Green 2002).

Distance Education

Distance education has been a significant feature of higher education for more than 60 years. Until the advent of electronic means of easy communication, distance education was mainly conducted through the mail, either as correspondence courses offered by traditional universities or as certification programs offered by for-profit correspondence schools. As electronic technology evolved, so did the principal means of delivery of distance education, advancing from courses delivered by radio (in the 1930s), television (in the 1950s), audio- or videocassettes (in the 1970s and 1980s), and computer and videoconferencing via satellite (in the 1990s) to the Internet, the most popular form of delivery from the 1990s to the present.

Distance education in U.S. colleges and universities expanded dramatically in the late 1990s, according to a nationally representative survey taken in 2000–01 (U.S. Department of Education 2003b). Both enrollment in for-credit distance education courses and the number of courses offered more than doubled from 1997–98 to 2000–01: enrollment grew from 1.3 million to 2.9 million, and course offerings grew from 47,500 to 118,000. In 2000–01, 56 percent (2,320) of 2- and 4-year institutions offered distance education courses, up from 44 percent 3 years earlier. However, percentages were much higher in public institutions. Almost 90 percent of public 2-year and 4-year institutions offered distance education courses; 16 percent of private 2-year and 40 percent of private 4-year institutions offered such courses. Still, fewer than 10 percent of students in S&E fields took courses through distance education.

Various technologies were used in delivering these distance courses. Ninety percent of the institutions offering distance education courses used online technologies such as the Internet and e-mail. A smaller percentage offered live interactive technologies, such as computer (43 percent) or video (51 percent) conferencing.

Rather than replacing traditional institutions, distance education enables these institutions to reach a wider audience for higher education. A National Center for Education Statistics (NCES) study on distance education conducted in 1999–2000 found that students taking advantage of distance education opportunities tended to be older (e.g., undergraduates age 24 years and older), have family responsibilities, and have limited time. They were more likely to be enrolled in public 2-year colleges, attend school part time, and work full time while enrolled (U.S. Department of Education 2003a).

Offering S&E courses through distance education has challenges and benefits. For example, one challenge is in equating experiences in virtual or online laboratories with traditional class laboratories. (See sidebar, "Distance Education: Problems and Successes.")

Distance Education: Problems and Successes

Problems with distance education, including accreditation, student assessment, course stability, international implementation, and delivery of laboratory courses online, occur in both traditional and nontraditional institutions.

The pace of introduction and use of distance education courses in online institutions, particularly for-profit institutions, has created some challenges in accreditation and transferability of courses. Although online institutions may be accredited by national agencies such as the Council for Higher Education Accreditation, they often have difficulty gaining accreditation by regional accreditation agencies, and thus the courses may not be accepted by more conventional universities. Online institutions report that they face a tougher problem in this aspect of accreditation than traditional institutions (Council for Higher Education Accreditation 2002 and Regional Accrediting Commissions 2001).

Allied to these problems is the difficulty of designing appropriate means by which to assess student performance, particularly in laboratory courses (Valentine 2002). For example, the Accreditation Board for Engineering and Technology is beginning to design standards for engineering laboratories and, with the help of the Alfred P. Sloan Foundation, is using a few test institutions to determine the usefulness of these standards when applied to courses delivered online (Feisel and Peterson 2002).

Some online science courses in chemistry and biology include simulated laboratories or base their laboratories on materials easily obtained from local sources. Although some of these laboratories have been successful, it is too early to tell whether these offerings will be equivalent to more conventional laboratories.

Successes and Failures

There have also been mixed signals about the stability of courses offered through small or large consortia. The newly initiated eArmyU, designed for traveling servicemen and -women, benefits from a well-organized base from which courses are offered. It recruits a cadre of institutions to offer courses and agree to standards for transferability (Arnone 2002). As of January 2003, 32 colleges were participating, offering more than 100 degree programs and enrolling more than 30,500 soldiers. Enrollment is expected to increase to 80,000 by 2005 (Carnevale 2003). For-profit ventures by conventional institutions do not appear to be faring as well. In January 2003, after 2 years of operation, Columbia University closed Fathom, its for-profit online learning venture that had been designed to sell Web-based courses and seminars to the public. This followed the demise of other ventures at New York University, Temple University, and the University of Maryland, College Park (Carlson 2003).

International Programs

Plans for offering international degree programs face major implementation difficulties. The University of Michigan recently abandoned its attempts to team with Shanghai Jiao Tong University to offer master's degrees in engineering to Chinese students through distance learning. The program was designed for evening and weekend courses, with the hope that Shanghai-based multinational companies (e.g., Whirlpool, General Motors, and Delphi) would be willing to pay to train local employees. However, although 20 students were expected, only 2 enrolled in the first year. Deterrents included high tuition and the fact that a degree from an American university, even from a prestigious institution like the University of Michigan, has less value if not combined with actual experience in the United States (Liu 2002).

New Types of Institutions

Certificate programs, for-profit colleges and universities, and various forms of industrial learning centers play a small but growing role in S&E higher education. Programs that award certificates have become an increasingly popular method for students and S&E professionals to learn a particular skill or expand their interest to a related field and to have their knowledge documented. General characteristics of graduate certificate programs are a focus on practical skills (e.g., hazardous waste management and infection control); fewer course requirements than for a master's degree (three to six specific courses); and, typically, an interdisciplinary scope (e.g., environmental ethics). Certificates represent a university's flexibility in a changing environment and an industry's need to upgrade the skills of its workers in emerging and rapidly changing fields. Although they are most commonly offered in health sciences, education, business, and IT, certificate programs are also offered in social sciences, environmental studies, engineering, and other sciences (Patterson 2001).[3]

Providers include 2- and 4-year colleges and universities of all types and the education units of various corporations (e.g., Microsoft, Cisco, Oracle, and Novell). In 2002, approximately 500 universities offered graduate certificate programs, up from 40 in 1997 (Patterson 2002). In some cases, the coursework may be applied to a degree program. Community colleges are also an important source of S&E-related certificate programs, particularly in health and computer sciences. In 2000, community colleges represented almost half of the academic providers of IT-related certificates.

Certificates can be earned through onsite or distance education and in some programs, particularly in IT, are awarded on completion of a skill-based exam, requiring no specific coursework. A Department of Education study in 2000 showed strong growth in exam-based certificates for the IT industry in the 1990s, extending well beyond the United States (U.S. Department of Education 2000b). In 1999, 5,000 sites in 140 countries were administering an estimated 3 million assessments in 25 languages. More than 300 discrete certifications have been established since 1989, when the first IT certificate (Certified Novell Engineer) was issued.

The percentage of students enrolled in for-profit institutions remains small, even though the number of institutions is growing. The Community College Research Center (CCRC) found that student enrollment in for-profit 2-year institutions accounted for 4 percent of total enrollment in 2-year institutions (Bailey, Badway, and Gumport 2003). Among 4-year institutions, the for-profit enrollment share was less than 2 percent. A report of the Education Commission of the States found that between 1989 and 1999, the number of for-profit 2-year degree-granting institutions grew 78 percent, representing 28 percent of all 2-year institutions in 1999. During the same period, the number of for-profit 4-year institutions grew by 266 percent (Bailey, Badway, and Gumport 2003).

Certificates accounted for 57 percent of all degrees awarded by U.S. for-profit 2-year institutions, which was more than awarded by public 2-year institutions (35 percent) (Bailey, Badway, and Gumport 2003). On the basis of case studies of three public community colleges and a for-profit chain, CCRC concluded that for-profit 2-year institutions are more appropriate for students interested in a narrowly focused career in a technical field, and community colleges are better suited to students who are interested in a general education or undecided on a major.

From 1988 to 2001, corporate "universities" grew from 400 to 2,000 (National Research Council 2002). Most of them primarily offer noncredit, nondegree courses narrowly targeted at retraining the workforce and other company needs. However, some large industries have internal training at a higher education level in engineering and design. For example, Motorola University contracts with 1,200 faculty worldwide who teach business and engineering wherever Motorola is designing innovative products.

Independent nonprofit institutions are also emerging to provide training geared specifically to corporate needs. These institutions offer credit-bearing courses and degree programs through IT and distance education. Institutions such as the Western Governors University and the United States Open University are recently formed examples. Since 1984, the National Technological University (NTU), a consortium of some 540 institutions, has been developing and offering courses and degree programs for engineering-oriented companies. The programs target engineering professionals interested in obtaining master's degrees in 1 of 18 engineering, technical, or business areas. All 1,300 academic courses offered by NTU are supplied by 52 leading engineering universities, including 25 of the top engineering schools in the country (National Research Council 2002).

For-profit and nonprofit subsidiaries of institutions and partnerships between 4-year institutions and private companies comprise a third type of industry learning center. The University of Maryland, College Park and eCornell are examples of for-profit or nonprofit subsidiaries of postsecondary education institutions. Both offer credit and noncredit courses to individuals and corporate universities. Motorola has partnerships with traditional institutions for sharing technology, faculty, and facilities. Motorola is part of a Ph.D. program at the International Institute of Information Technology (formerly the Indian Institute of Information Technology) in Hyderabad, India, and degree programs at Morehouse College in Atlanta, Georgia, and Roosevelt University in Chicago, Illinois (Wiggenhorn 2000).

Enrollment in Higher Education

Overall Enrollment

Overall enrollment in U.S. institutions of higher education increased from about 7 million in 1967 to 14.5 million in 1992, remained at that level until 1997, and rose to 15.6

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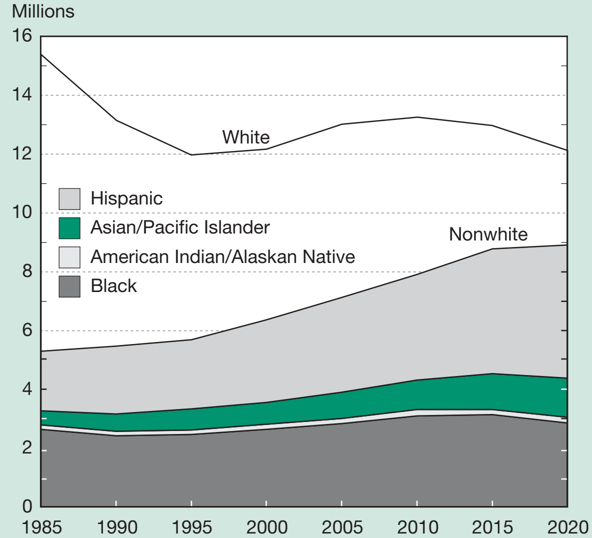
[3]A listing of graduate certificate programs can be found at http://www.certificates.gradschools.com.

million by 2000. These increases differed for various groups (table 2-1 and appendix table 2-2). Enrollment is projected to increase in the first 2 decades of the 21st century for two reasons. First, the number of students of college age (approximated by the size of the 20–24-year-old cohort) is projected to grow. In the late 1990s, the U.S. college-age population reversed its 2-decade-long decline and began an upward trend. After decreasing from 21.5 million in 1981 to 17.4 million in 1997 (about 19 percent), the college-age population reached 18.5 million by the 2000 census and is expected to increase to 21.7 million by 2015 (appendix table 2-4).[4] Second, increasing numbers of students who are older than 24 years are enrolling in higher education. More than 50 percent of all undergraduates are 22 or older; almost 25 percent are 30 or older (Edgerton 2001).

The increased enrollment is projected to come from minority groups, principally from Hispanics, a group that has not traditionally studied S&E fields to the same extent as the majority white population. (See "Undergraduate Enrollment in S&E.") From 2000 to 2015, the Hispanic college-age population is projected to increase by 52 percent, nearly as high as the rise in Asian/Pacific Islanders (62 percent); those of blacks and American Indian/Alaskan Natives will rise by 19 and 15 percent, respectively. The white college-age cohort, which declined until 2000, is expected to rise by 7 percent, should expand slowly until about 2010, and should then decline again (figure 2-3 and appendix table 2-4).

The changing demographic composition of higher education can already be seen by comparing 1992 and 1998 data. During this period, overall enrollment increased by 1 percent, but underrepresented minority enrollment grew by 16 percent and Asian/Pacific Islander enrollment by 36 percent. In 1998, underrepresented minority students were more often enrolled than U.S. citizens overall in 2-year institutions (43 versus 39 percent) and less often in research institutions (12 versus 18 percent). (For a breakout of enrollment trends by institutional type and race/ethnicity in the 1990s, see appendix table 2-5.)

Figure 2-3
U.S. population of 20–24-year-olds, by race/ethnicity: Selected years, 1985–2020



SOURCES: U.S. Bureau of the Census, Population Division, 1990 Census; and U.S. Bureau of the Census, Population Projections Program, *Projections of the Resident Population by Age, Sex, Race, and Hispanic Origin: 1999 to 2100.* See appendix table 2-4.

Science & Engineering Indicators – 2004

Undergraduate Enrollment in S&E

Enrollment in undergraduate S&E courses and majors prepares students to study S&E at more advanced levels. It also prepares them to work in occupations that require the knowledge and skills acquired in the pursuit of an S&E education.

Table 2-1
Growth in higher education enrollment, by sex, race/ethnicity, and visa status: 1986–98
(Index: 1986 = 100)

Sex, race/ethnicity, and visa status	1986	1989	1992	1995	1998
All students	100	108	116	114	116
Male	100	101	111	108	108
Female	100	110	120	120	123
White	100	108	112	106	105
Asian	100	124	161	184	208
Underrepresented minorities	100	114	138	150	165
Black	100	112	131	138	149
Hispanic	100	117	147	167	188
American Indian/Alaskan Native	100	111	136	150	165
Temporary resident	100	112	133	135	132

NOTE: Race/ethnicity breakdown does not include temporary residents.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov.

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[4]For data on earlier years, see appendix table 2-32.

Table 2-2
Freshmen who took recommended college-preparatory courses in high school, by intended major: 1983 and 2001
(Percent)

Course	Minimum years taken	Non-S&E major		S&E major	
		1983	2001	1983	2001
English	4.0	93.9	97.8	94.6	97.9
Mathematics	3.0	87.3	97.8	94.9	98.6
Foreign language	2.0	70.6	92.4	75.2	93.5
Physical sciences[a]	2.0	51.7	55.2	66.1	63.1
Biological sciences	2.0	35.8	43.2	35.6	45.7
Computer sciences	0.5	51.6	61.6	63.8	63.6

[a]Physical sciences include physics, chemistry, astronomy, and earth, atmospheric, and ocean sciences.

SOURCE: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, special tabulations, 2003.

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Freshmen Intentions to Major in S&E

The annual freshman norms survey, administered by the Higher Education Research Institute (HERI), indicates the distribution of future S&E (and other) bachelor's degrees. Since 1972, the survey has asked freshmen at numerous universities and colleges about their degree intentions, and the data have given a general picture of degree trends several years later.[5]

According to the HERI survey, freshmen from all demographic groups plan to study S&E. In recent years, approximately 31 percent of white, 43 percent of Asian/Pacific Islander, and 35 percent of underrepresented minority freshmen reported that they intended to major in S&E. The proportions were higher for men in every racial/ethnic group. In the 1990s, more men from every racial/ethnic group reported interest in a computer science major than before. However, in 2001 and 2002, the number of freshman intending to major in computer sciences dropped off for every race and ethnicity (appendix table 2-6).

The growing diversity of the college population is mirrored in the changing mix of students studying S&E. Women constituted 33 percent of students reporting S&E intentions in 1972, rising gradually to 44 percent by the late 1990s. The data also show increasing racial/ethnic diversity among freshmen intending to pursue an S&E major. By 1996, members of underrepresented minority groups accounted for almost 20 percent of those planning an S&E major, up from 8 percent in the early 1970s. After 1996, the percentages for underrepresented minorities fluctuated around 19 percent, with shifts among S&E fields. In the late 1990s, more underrepresented minorities intended majors in biological/agricultural and social/behavioral sciences, and fewer intended majors in computer sciences and engineering (appendix table 2-7).

Few of those intending an S&E major consider teaching as a probable career, whether at the elementary, secondary, or college level. In the past decade, fewer anticipated becoming engineers or scientific researchers than in previous decades. Instead, more anticipated becoming computer scientists or physicians.

Based on coursetaking, survey responses indicate that freshmen are at least as ready for college-level coursework as in the past. Respondents reported taking more of the recommended college-preparatory high school courses than in prior years (table 2-2). However, 20 percent of the 2002 respondents intending an S&E major reported needing remediation in mathematics, and nearly 10 percent reported needing remediation in the sciences. These percentages have been relatively stable over 2 decades (appendix table 2-8). Need for remediation varied depending on the major field: fewer intending to major in mathematics, physical sciences, or engineering reported a need for remediation compared with those intending to major in social or behavioral sciences or in non-S&E fields (figure 2-4).

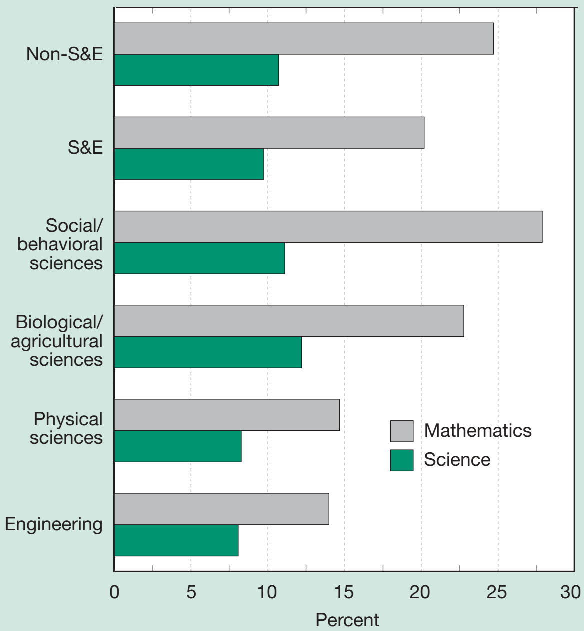
Retention in S&E

Students change their majors during their undergraduate years or after completing an S&E degree, and S&E fields are not alone in experiencing attrition between freshman intentions and undergraduate outcomes. Two studies of student retention in S&E cast some light on what happens between declaration of a degree intention and the moment a degree is awarded. Retention in S&E careers or in advanced education of those who complete S&E degrees is shown in the National Science Foundation (NSF) National Survey of Recent College Graduates (NSRCG).

An NCES longitudinal study followed first-year students in 1990 who intended to complete an S&E major and found that fewer than half had completed an S&E degree within 5 years. Approximately 20 percent of the students dropped out of college, and the others chose other fields (U.S. Department of Education 2000a). The study also found that underrepresented minorities were more likely than students from other groups to drop out of S&E programs. NCES

[5]The number of S&E degrees awarded to a particular freshmen cohort is lower than the number of students reporting such intentions and reflects losses of students from S&E, students moving into S&E after their freshman year, and general attrition from bachelor's degree programs. See "Retention in S&E."

Figure 2-4
Freshmen reporting need for remediation in mathematics or science, by intended major: 2002



NOTE: Physical sciences include physics, chemistry, astronomy, and earth, atmospheric, and ocean sciences.

SOURCE: Higher Education Research Institute, Survey of the American Freshman: National Norms*.* See appendix table 2-8.

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did not collect data on students who moved into S&E from other fields.

A more recent study focused on 1993 freshmen with a declared S&E major at 175 universities and colleges varying in size, selectivity, and highest degree level (Center for Institutional Data Exchange and Analysis 2001). Like the NCES study, this study found that fewer than half of the students had completed an S&E degree after 6 years. It also documented that women and underrepresented minorities left S&E programs at higher rates than men and nonminority students, resulting in lower degree completion rates for women and minorities. Retention rates for those who had declared an intention to major in S&E were higher at institutions that shared the characteristics of high selectivity, low part-time attendance, doctoral degree level, and private governance.

The NSRCG shows retention in S&E as measured through further education and S&E occupations. About one-third of those who graduated with an S&E bachelor's degree in 1999 or 2000 were continuing in S&E in 2001, either in graduate study (13 percent) or employment (20 percent).[6] Percentages of those going on for advanced study in S&E were higher for those with a high grade point average (GPA). More than 18 percent of those with a 3.75–4.00 undergraduate GPA continued to study S&E. In contrast, relatively few (7 percent) of those with less than 2.75 GPA continued to study S&E. Retention rates in S&E from the 2001 survey were up slightly from the 1995 survey (appendix table 2-9).

Retention in S&E after completion of an S&E master's degree was higher than after completion of a bachelor's degree. In 2001, around 63 percent of those who earned an S&E master's degree in 1999 or 2000 were continuing in S&E, either in school (17 percent) or in employment (46 percent). Overall, S&E retention after a master's degree in 2001 was similar to that in 1995, but a larger percentage of these graduates were employed in S&E fields in 2001 than in 1995, and a small percentage were continuing advanced studies in S&E fields (appendix table 2-9).

Enrollment Trends in Mathematics and Statistics

Mathematics and statistics are increasingly important as analytic tools across the sciences. The Conference Board of Mathematical Sciences compiles data every 5 years on enrollment in mathematics and statistics courses (Lutzer, Maxwell, and Rodi 2002). Enrollment in 4-year institutions reached a low in 1995 but rebounded in 2000. Course-level differences were reflected in the degree of recovery. In universities and 4-year colleges, the number of students increased primarily in introductory mathematics and statistics courses. However, more students than before also enrolled in level 1–4 calculus courses. Enrollment in advanced undergraduate courses rose only slightly from the 1995 low, but because completion of the calculus series is a prerequisite for such courses, enrollment in advanced courses is expected to increase after 2000 (table 2-3).

In the past 2 decades, the proportion of enrollment in remedial mathematics courses increased at 2-year institutions and declined at 4-year institutions. In 2000, enrollment in remedial mathematics courses accounted for 60 percent of all mathematics enrollment in 2-year institutions, up from 48 percent in 1980. In the same period, enrollment in remedial mathematics courses at 4-year institutions declined to 14 percent of total mathematics enrollment, down from 16 percent in 1980. Neither of these trends is a reliable indicator of changes in student preparation, however. In general, enrollment in remedial courses includes many older adults taking refresher courses (Phillippe and Patton 1999), a phenomenon that is widespread at 2-year institutions. The decline at 4-year institutions may reflect the effort of some states to remove remedial courses from their 4-year colleges and universities.

Enrollment Trends in Engineering

Generally, engineering programs require students to declare a major in the first year of college, making enrollment data an early indicator of both future undergraduate engineering degrees and student interest in an engineering career. The Engineering Workforce Commission (2003)

[6]Many occupations not classified as S&E (e.g., elementary/secondary school teacher, manager) require significant scientific or technical background. See "How Are People With an S&E Education Employed?" in chapter 3.

Table 2-3
Estimated enrollment in undergraduate mathematics and statistics courses: 1980–2000

Institution and course level	1980		1985		1990		1995		2000	
	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent	Thousands	Percent
4-year institutions										
All mathematics	1,525	100.0	1,619	100.0	1,619	100.0	1,469	100.0	1,614	100.0
Remedial	242	15.9	251	15.5	261	16.1	222	15.1	219	13.6
Introductory	602	39.5	593	36.6	592	36.6	613	41.7	723	44.8
Calculus	590	38.7	637	39.3	647	40.0	538	36.6	570	35.3
Advanced	91	6.0	138	8.5	119	7.4	96	6.5	102	6.3
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
All statistics	NA	NA	NA	NA	169	10.4	208	14.2	245	15.2
Elementary	NA	NA	NA	NA	117	7.2	164	11.2	190	11.8
Upper level	NA	NA	NA	NA	52	3.2	44	3.0	55	3.4
2-year institutions										
All mathematics	925	100.0	900	100.0	1,241	100.0	1,384	100.0	1,273	100.0
Remedial	441	47.7	482	53.6	724	58.3	800	57.8	763	59.9
Introductory	180	19.5	188	20.9	245	19.7	295	21.3	274	21.5
Calculus	86	9.3	97	10.8	128	10.3	129	9.3	106	8.3
Advanced	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Other	218	23.6	133	14.8	144	11.6	160	11.6	130	10.2
All statistics	28	3.0	36	4.0	54	4.4	72	5.2	74	5.8
Elementary	28	3.0	36	4.0	54	4.4	72	5.2	74	5.8
Upper level	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA not available

NOTES: The curriculum of course levels differs between 2-year mathematics programs and 4-year mathematics departments. However, remedial courses generally include high school-level courses in elementary and intermediate algebra and geometry. Introductory mathematics courses include college algebra, trigonometry, precalculus, and courses for non-science majors. Other mathematics courses in 2-year programs include linear algebra, discrete and finite mathematics, probability, and mathematics for liberal arts majors and prospective elementary school teachers.

SOURCE: D. J. Lutzer, J.W. Maxwell, and S.B. Rodl. *Statistical Abstract of Undergraduate Programs in the Mathematical Sciences in the United States, Fall 2000 CBMS Survey,* (Washington, DC: American Mathematical Society, 2002).

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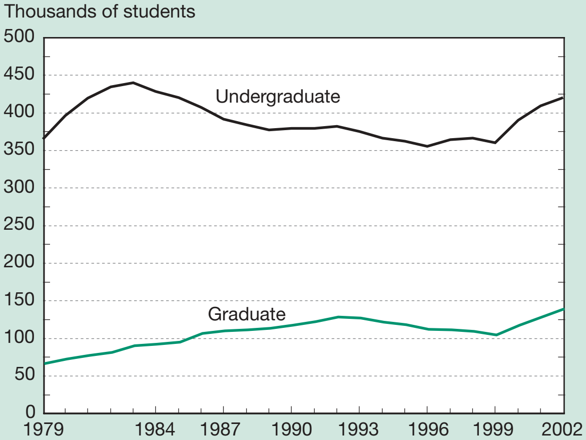
administers an annual fall survey that tracks enrollment in undergraduate and graduate engineering programs.

Undergraduate engineering enrollment decreased sharply during the 1980s, followed by slower declines in the 1990s and rising numbers from 2000 to 2002 (figure 2-5). From a 1983 peak of about 441,000 students, undergraduate engineering enrollment declined to about 361,000 students by 1999, an 18 percent drop, before rebounding to 421,000 in 2002 (appendix table 2-10). Graduate engineering enrollment peaked in 1993 at 128,000, declined to 105,000 by 1999, and then rebounded past its former peak to an all-time high of 140,000 in 2002 (appendix table 2-11).

Figure 2-5
U.S. engineering enrollment, by enrollment level: 1979–2002



NOTE: Enrollment data include full- and part-time students.

SOURCE: Engineering Workforce Commission, *Engineering and Technology Enrollments, 2002–2003.* See appendix table 2-11.

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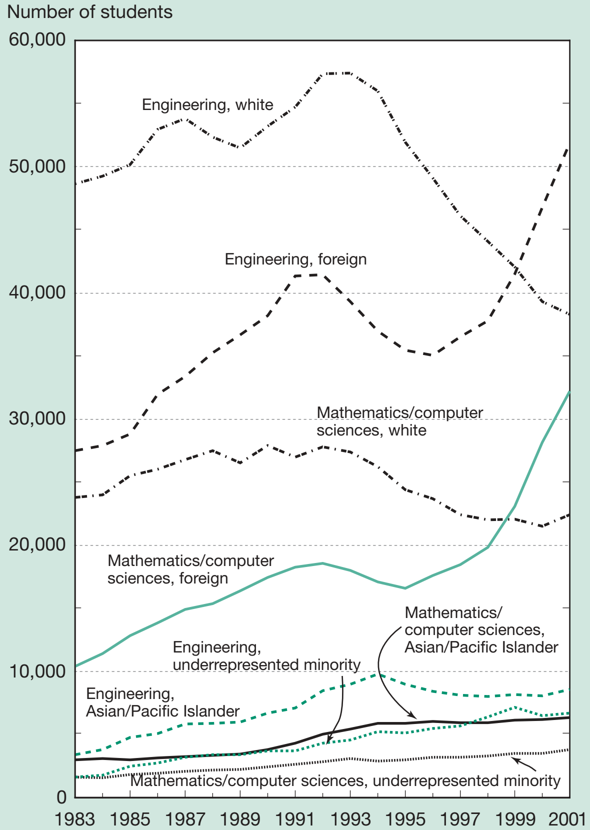
Graduate Enrollment in S&E

Advanced education in S&E toward a master's or doctoral degree prepares people for more technically oriented occupations, teaching in these fields, and research and research management positions. This section presents data on continuing key trends in graduate S&E enrollment. Information is included on patterns and trends showing how graduate students are supported during their education.

Enrollment Trends

The long-term growth trend in U.S. S&E graduate enrollment reached a peak of 435,700 in 1993. This was followed by a 5-year decline, with a recovery of growth to nearly the 1993 level by 2001. Graduate enrollment in engineering and computer sciences drove the recent growth; enrollment in most other science fields remained level or declined. By 2001, graduate enrollment in physical, earth, atmospheric, and ocean sciences had declined by 12 percent from their highs, and enrollment in mathematics declined by 17 percent. The increase in computer sciences and recent recovery in engineering mainly reflect the increasing number of foreign graduate students enrolling in these programs (figure 2-6 and appendix table 2-12).

Figure 2-6
Graduate enrollment in mathematics/computer sciences and engineering, by citizenship and race/ethnicity: 1983–2001



NOTES: Foreign citizen includes temporary residents only. Race/ethnicity groups include U.S. citizens and permanent residents. Underrepresented minority includes black, Hispanic, and American Indian/Alaskan Native.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-12.

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The long-term increase in overall graduate enrollment was the combined result of strong growth in foreign student enrollment (about 90 percent from 1983 to 2001), continuing increases in the number of women, and an approximate doubling in enrollment for each underrepresented minority group (appendix tables 2-12 and 2-13). These trends more than balanced a decline in the number of white men (table 2-4). Short-term trends in S&E graduate enrollment are shown in table 2-5.

The number of women enrolling in S&E graduate programs has continued to increase for the past 2 decades, except for a leveling off in psychology in the last half of the 1990s (appendix table 2-13). The long-term trend of the rising proportion of women in S&E fields also continued, but large variations among fields persisted. By 2001, women constituted most of the graduate enrollment in psychology (74 percent), biology (54 percent), and social sciences (52 percent). They constituted considerable proportions of graduate students in mathematics (38 percent) and physical, earth, atmospheric, and ocean sciences (34 percent). Women remain underrepresented in two broad fields: computer sciences (29 percent) and engineering (20 percent) (figure 2-7).

The proportion of underrepresented minority students in graduate S&E programs increased from about 6 percent in 1983 to 10 percent in 2001, well below their share in the college-age population (30 percent). However, measured as a percentage of U.S. citizens and permanent residents, their share has gone from 7 to 14 percent, approximating their share of S&E baccalaureates (16 percent). Over the period, average annual enrollment growth of underrepresented minorities was 3.9 percent, with little difference among groups; however, in the 1987–93 period, growth averaged nearly 8 percent a year, slowing to 3.4 percent annually thereafter (appendix table 2-12).

Foreign graduate student enrollment in S&E grew from 70,200 in 1983 to 133,300 in 2001, with some years of decline in the early to mid-1990s. For all S&E fields combined, the proportion of foreign students increased from 20 to 31 percent over the period (appendix table 2-12). Eight of the top 10 countries/economies of origin for foreign S&E graduate students in U.S. institutions in the 1990s were Asian, with Canada and Mexico being the exceptions (appendix table 2-14).

Over the 1983–2001 period, approximately 70 percent of the growth in the number of foreign graduate students in S&E occurred in just two fields: engineering and computer sciences. Engineering enrollment peaked in 1993, declined steeply for several years, and rebounded after 1995. Computer science enrollment rose through most of the period, with a brief drop in the mid-1990s, followed by a rapid increase (appendix table 2-12). By 2001, foreign students represented 49 percent of all graduate students in computer sciences and 47 percent in engineering. They also represented large percentages of graduate students in mathematics and physical sciences (figure 2-8).

Table 2-4
S&E graduate enrollment by citizenship and race/ethnicity: 1983–2001

Citizenship and race/ethnicity	1983	1993	2001
All S&E graduate students	346,952	435,703	429,492
U.S. citizen/permanent resident	276,749	330,037	296,194
White	224,604	256,755	205,757
Asian/Pacific Islander	9,387	24,047	27,659
Black	10,941	17,111	21,773
Hispanic	8,810	13,380	17,983
American Indian/Alaskan Native	911	1,309	1,687
Unknown race/ethnicity	22,096	17,435	21,335
Foreign citizen[a]	70,203	105,666	133,298

[a]Includes temporary residents only.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-12.

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Financial Support for S&E Graduate Education

U.S. higher education in S&E fields couples advanced education with research. Students' sources of financial support during graduate school can affect the character of their graduate education, including the kinds of research skills they learn, choices of research direction, and preparation for different careers. Support mechanisms include research assistantships (RAs), teaching assistantships (TAs), fellowships, and traineeships.

Sources of funding include Federal agency support, non-Federal support, and self-support. Non-Federal support includes state funds, particularly in the large public university systems; these funds are affected by the condition of overall state budgets. (See sidebar, "Definitions and Terminology of Support," for more detailed descriptions of mechanisms and sources of support.) Most graduate students, especially those who pursue doctoral degrees, are supported by more than one source and one mechanism during their time in graduate school, and some receive support from several different sources and mechanisms in a given academic year.

This section describes patterns and trends in student reliance on different mechanisms and sources of financial support.

RAs became more prominent during the latter 1980s and have accounted for 27–28 percent of total graduate support since 1988. The prevalence of traineeships and TAs declined during the 1990s; self-support reached about 33 percent during the second half of the decade (table 2-6).

In 2001, one in five graduate students received Federal financial support. This support was mostly in the form of RAs—67 percent, up from 55 percent 2 decades earlier—and was offset by declining traineeships. For students supported through non-Federal sources in 2001, TAs were the most prominent mechanism (40 percent), followed by RAs (32 percent) (appendix table 2-15).

Primary mechanisms of support differ widely by S&E field of study. For example, in 2001, students in physical sciences were supported mainly through RAs (43 percent) and TAs (39 percent). RAs were also important in engineering (42 percent). In mathematics, however, primary student support was through TAs (55 percent) and self-support (16 percent). Students in social and behavioral sciences were

Table 2-5
Change in S&E graduate enrollment, by citizenship, race/ethnicity, and sex: 1994–2001
(Percent)

Citizenship and race/ethnicity	All	Male	Female
All S&E graduate students	0	–7	12
U.S. citizen/permanent resident	–10	–19	3
White	–20	–26	–9
Asian/Pacific Islander	24	17	28
Black	24	5	39
Hispanic	35	19	56
American Indian/Alaskan Native	22	–7	28
Foreign citizen[a]	31	22	56

[a]Includes temporary residents only.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov.

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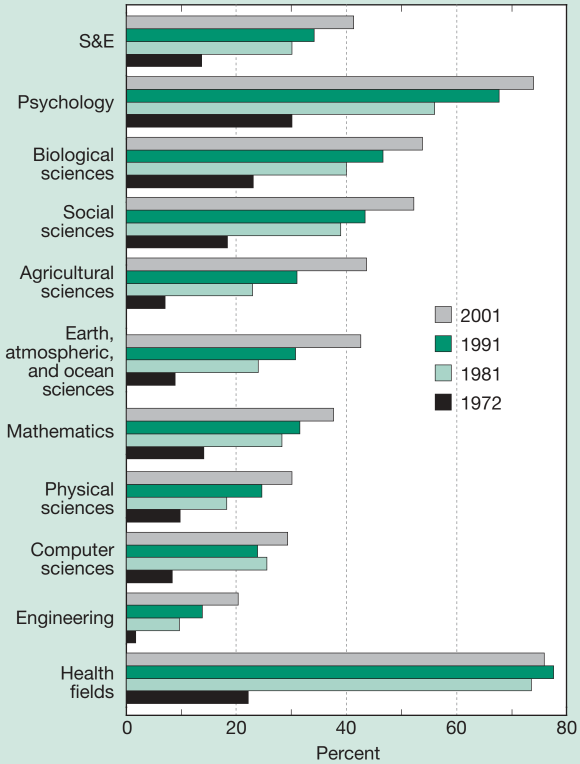
Figure 2-7
Female U.S. graduate S&E enrollment, by field: Selected years, 1972–2001



NOTE: Health fields not included in S&E total.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-13.

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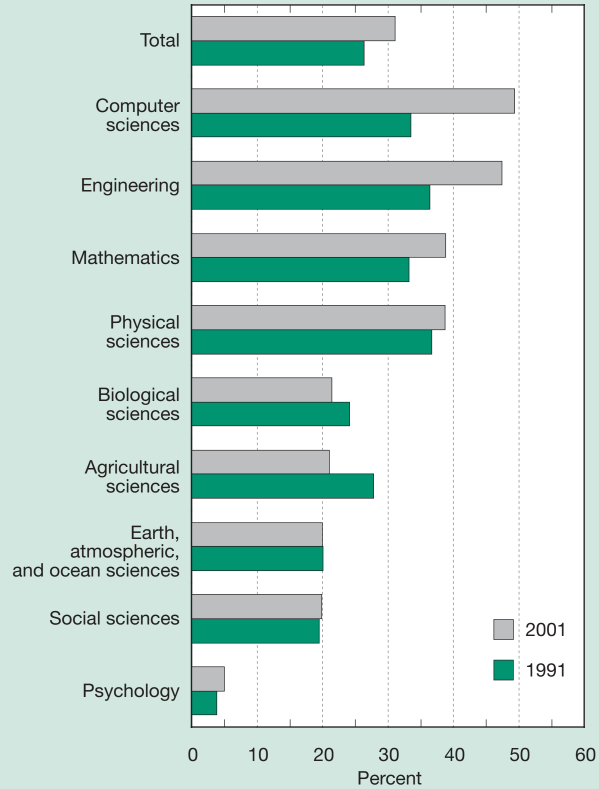
Figure 2-8
Foreign student share of U.S. graduate S&E enrollment, by field: 1991 and 2001



SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-12.

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Definitions and Terminology of Support

Mechanisms of support: These may come from Federal or non-Federal sources.

Research assistantships (RAs) are given to students whose assigned duties are devoted primarily to research.

Teaching assistantships (TAs) are given to students whose assigned duties are devoted primarily to teaching.

Fellowships are competitive awards (often from a national competition) given to students for financial support of their graduate studies.

Traineeships are educational awards given to students selected by the institution.

Other mechanisms of support include work-study programs, business or employer support, and support from foreign governments other than a previously mentioned mechanism.

Sources of support: Except for self-support, funds may take the form of any mechanism; institutional support may take the form of tuition remission.

Federal support is provided by Federal agencies, chiefly in the form of RAs and traineeships; it also includes items such as tuition paid by the Department of Defense for members of the Armed Forces.

Non-Federal support is provided by the institution of higher education, state and local governments, foreign sources, nonprofit institutions, or private industry.

Self-support is derived from any loans obtained (including Federal loans) or from personal or family contributions.

Table 2-6
Support mechanisms of full-time S&E graduate students: 1980–2001
(Percent distribution)

Year	All mechanisms	Research assistantship	Fellowship	Traineeship	Teaching assistantship	Other	Self-support
1980	100.0	21.6	8.6	7.4	22.6	8.2	31.6
1983	100.0	21.8	8.5	5.4	23.8	8.3	32.2
1986	100.0	24.8	8.6	5.1	23.5	8.4	29.6
1989	100.0	28.0	8.3	5.1	22.7	7.5	28.4
1992	100.0	27.3	8.9	4.8	20.4	7.3	31.4
1995	100.0	27.3	8.8	4.8	20.0	6.6	32.4
1998	100.0	26.9	8.9	4.6	19.9	6.7	33.1
2001	100.0	28.1	9.1	4.0	19.1	6.7	33.0

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-15.

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mainly self-supporting (43 percent) or received TAs (20 percent) (appendix table 2-16).

The Federal Government plays a significant role in supporting S&E graduate students in some mechanisms and fields and a small role in others. For example, in 2001, the Federal Government sponsored 59 percent of S&E traineeships, 47 percent of RAs, and 22 percent of fellowships.[7] Federal support reaches relatively large proportions of students in physical, earth, atmospheric, ocean, and life sciences and engineering. However, few students receive Federal support in mathematics, computer sciences, social sciences, and psychology (figure 2-9). Appendix table 2-17 gives detailed information by field and mechanism.

The National Institutes of Health (NIH) and NSF support most of the S&E graduate students whose primary support comes from the Federal Government. In 2001, they supported about 20,000 and 15,000 students, respectively. Two-decade trends in Federal agency support of graduate students showed considerable increases in the proportion of students funded (NIH, from 22 to 29 percent; NSF, from 18 to 23 percent). Support from the Department of Defense declined during the 1990s (appendix table 2-18).

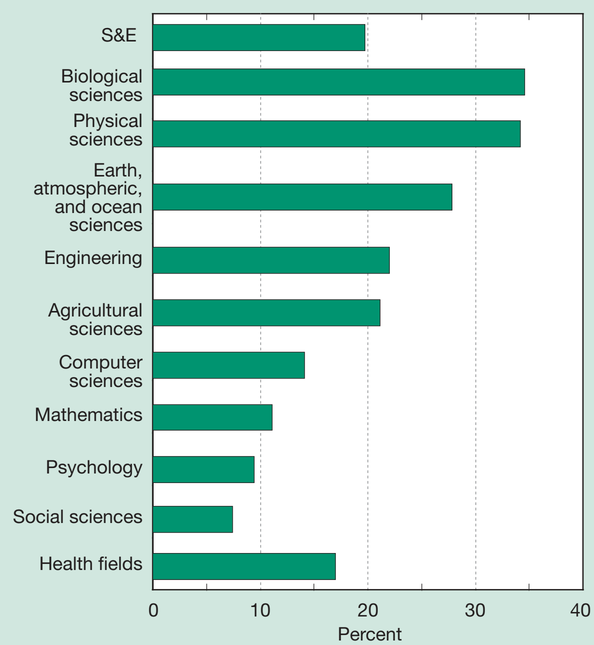
For doctoral degree students, notable differences exist in primary support mechanisms by sex, race/ethnicity, and citizenship. In 2001, men were most likely to be supported by RAs (30 percent), and women were most likely to support themselves from personal sources of funds (34 percent). Whites and Asian/Pacific Islanders were most likely to derive primary support from RAs (26 and 31 percent, respectively), and underrepresented minorities depended more on fellowships (36 percent). The primary source of support for foreign doctoral degree students was an RA (table 2-7).

[7]Federal fellowships and traineeships are available only to U.S. citizens and permanent residents; however, this does not apply to Federal research assistantships.

Higher Education Degrees

Degree conferral represents the certification of achievement at various levels of education and training. Over the years, U.S. colleges and universities have awarded rising numbers of associate's, bachelor's, master's, and doctoral degrees in all fields. The number of degrees in S&E fields has generally risen along with other fields.

Figure 2-9
Full-time S&E graduate students with primary support from Federal Government, by field: 2001



NOTE: Health fields not included in S&E total.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-17.

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Table 2-7
Selected primary mechanisms of support for S&E doctorate recipients, by citizenship, sex, and race/ethnicity: 2001
(Percent distribution)

Citizenship, sex, and race/ethnicity	All mechanisms	Research assistantship	Fellowship	Teaching assistantship	Other	Personal
U.S. citizen	100.0	25.4	23.5	14.9	11.7	24.5
Male	100.0	29.9	23.0	15.7	11.8	19.5
Female	100.0	19.8	24.1	13.8	11.6	30.8
White	100.0	26.2	21.3	15.9	11.3	25.2
Asian/Pacific Islander	100.0	31.4	30.0	10.9	13.3	14.3
Underrepresented minority	100.0	13.5	37.8	9.8	12.4	26.4
Temporary resident	100.0	46.0	15.9	17.0	15.0	6.1

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-19.

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S&E Associate's Degrees

Associate's degrees, largely offered by 2-year programs at community colleges, offer basic technical certification, primarily in computer and social science, engineering, and technology fields. S&E associate's degrees rose from 26,500 in 1985 to 33,700 in 2000. The increase in the late 1990s was mainly attributed to computer sciences, which represented 56 percent of all S&E associate's degrees by 2000. In contrast, the number of associate's degrees in natural sciences and engineering decreased in the late 1990s. Degrees earned in engineering technologies (not included in S&E totals because of their practice-focused nature) remained more numerous than degrees in S&E fields but experienced a steady decline during the past 2 decades (appendix table 2-20).

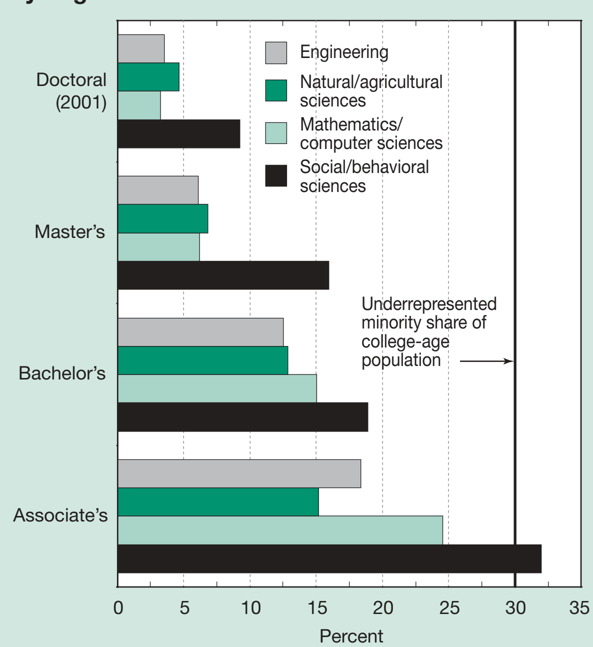
Race/ethnicity trends in the number of associate's degrees earned are shown in appendix table 2-21. Students from underrepresented groups earn a considerably higher proportion of associate's degrees than of bachelor's or more advanced degrees. In 2000, their proportion of associate's degrees was 32 percent for social and behavioral sciences and about 25 percent for mathematics and computer sciences (figure 2-10). The proportion of computer science degrees earned by these students has almost doubled since 1985.

S&E Bachelor's Degrees

The ratio of bachelor's degrees to the size of the college-age cohort (24-year-olds are a proxy) is a useful indicator of educational achievement. This ratio has risen from 21.8 per 100 in 1980 to 33.8 per 100 in 2000. The ratio of bachelor's degrees in natural, agricultural, and computer sciences; mathematics; and engineering (NS&E) to the population cohort stood between 4 and 5 per 100 for several decades but increased to 5.7 in the late 1990s, largely on the strength of increases in computer science baccalaureates (National Science Board 2002 and table 2-8).

The annual output of S&E bachelor's degrees rose steadily from 303,800 in 1977 to about 398,600 in 2000; they represented approximately one-third of baccalaureates over the entire period. However, these consistent trends mask considerable variations among fields (figure 2-11). The number of earned degrees in engineering and computer sciences grew sharply in the early 1980s, peaked in 1986, and then dropped precipitously before leveling off in the 1990s. In the 1990s, degrees in biological and agricultural sciences and psychology began a steady increase. By 1992,

Figure 2-10
Underrepresented minority share of S&E degrees, by degree level and field: 2000 or 2001



NOTES: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences. Underrepresented minority includes black, Hispanic, and American Indian/Alaskan Native.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix tables 2-21, 2-23, 2-25, and 2-27.

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Table 2-8
Ratio of bachelor's degrees to the 24-year-old population, by selected fields, sex, and race/ethnicity: 1990 and 2000

Sex and race/ethnicity	Degree: All bachelor's degrees	Degree: All S&E	Degree: NS&E	Degree: Social/behavioral sciences	24-year-old population	Degree: Bachelor's	Degree: NS&E[a]	Degree: Social/behavioral science
	Number					Ratio to 24-year-old population[b]		
1990 total	1,062,160	345,794	169,938	175,856	3,722,737	28.5	4.6	4.7
Male	495,876	199,917	117,249	82,668	1,855,513	26.7	6.3	4.5
Female	566,284	145,877	52,689	93,188	1,867,224	30.3	2.8	5.0
White	856,686	270,225	127,704	142,521	2,628,439	32.6	4.9	5.4
Asian/Pacific Islander	38,027	19,437	13,338	6,099	120,797	31.5	11.0	5.0
Underrepresented minority	107,377	33,419	15,259	18,160	973,500	11.0	1.6	1.9
Black	59,301	18,230	7,854	10,376	484,754	12.2	1.6	2.1
Hispanic	43,864	13,918	6,868	7,050	459,073	9.6	1.5	1.5
American Indian/Alaskan Native	4,212	1,271	537	734	29,674	14.2	1.8	2.5
2000 total	1,253,121	398,622	210,434	188,188	3,703,200	33.8	5.7	5.1
Male	536,158	197,669	128,111	69,558	1,886,400	28.4	6.8	3.7
Female	716,963	200,953	82,323	118,630	1,816,800	39.5	4.5	6.5
White	895,129	270,416	142,400	128,016	2,433,400	36.8	5.9	5.3
Asian/Pacific Islander	75,265	12,368	23,185	12,368	148,800	50.6	15.6	8.3
Underrepresented minority	200,967	63,519	27,939	35,559	1,121,000	17.9	2.5	3.2
Black	104,212	32,924	13,795	19,129	527,600	19.8	2.6	3.6
Hispanic	88,324	27,984	12,919	15,065	560,200	15.8	2.3	2.7
American Indian/Alaskan Native	8,431	2,611	1,246	1,365	33,200	25.4	3.8	4.1

NS&E natural sciences and engineering

[a]NS&E degrees include natural (physical, biological, earth, atmospheric, and ocean sciences), agricultural, and computer sciences; mathematics; and engineering.
[b]Number of degrees per 100 24-year-olds.

NOTE: Degrees by race/ethnicity do not sum to total because data not shown for unknown race/ethnicity or foreign citizens.

SOURCES: U.S. Department of Education, Completions Survey; National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov; and U.S. Bureau of the Census, Population Division. See appendix tables 2-4, 2-22, and 2-23.

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the number of psychology degrees surpassed the number earned in engineering, and, in 1997, biological and agricultural sciences surpassed engineering as well. After 1997, degrees in engineering began to decline further, but those in computer sciences increased sharply, almost reaching their mid-1980s level by 2000 (appendix table 2-22).

Trends in earned degrees in broad fields can mask differences among subfields. For example, within the decline in physical sciences in the 1990s, degrees in chemistry actually increased. Similarly, declines in social sciences masked divergent trends; degrees in sociology continued to increase, whereas those in economics declined from their peak in the early 1990s (NSF/SRS 2002).

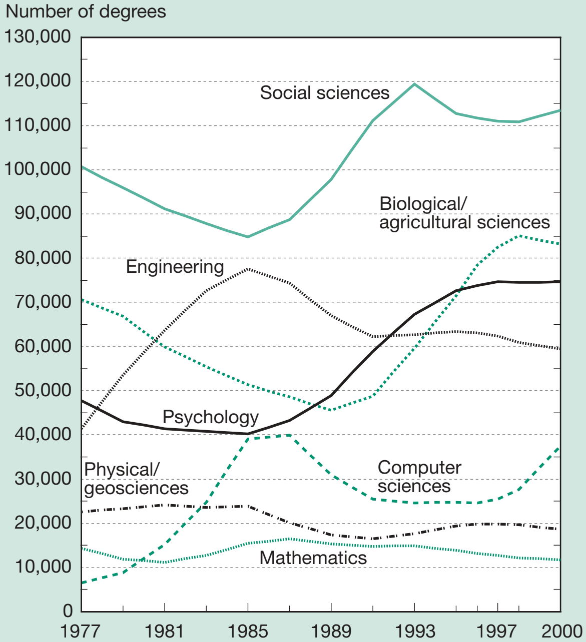
Innovations in Undergraduate S&E Education

Concerns about the growing need for scientifically trained workers and scientifically literate citizens have prompted the higher education community to examine the quality of the undergraduate experience and explore new approaches. Several recent studies called for reform (Association of American Colleges and Universities 2002; National Research Council 2002, 2003a, and 2003b; and Project Kaleidoscope 2002). These studies have common themes, including urging S&E educators to move toward more interdisciplinary education and more fully incorporate mathematical approaches; giving students experience in retrieving and manipulating large databases; exploring the use of electronic delivery; involving students in dialogue about their study topics; and providing research experiences early in students' academic careers, both in regular classroom settings and as part of a research team external to the classroom laboratory. The sidebar "Bioinformatics" describes how these changes are being manifested in life sciences.

Innovations are also under way to improve teaching, both at the undergraduate level and in K–12. Science funding agencies and professional societies support faculty to design, test, and improve computer-driven classes. The Federal Government has developed repositories of teaching materials, such as the Department of Education's Eisenhower National Clearinghouse for Mathematics and Science Education and NSF's National Science, Technology, Engineering and Mathematics Education Digital Library. Programs that recognize and reward outstanding teachers and scholars highlight the value of integrating research and education during the undergraduate years.[8] Other programs recognize

[8]For example, the NSF Director's Award for Distinguished Teaching Scholars and the Howard Hughes Medical Institute Award, which further the participation of forefront S&E faculty in undergraduate education at research universities.

Figure 2-11
S&E bachelor's degrees, by field: Selected years, 1977–2000



NOTE: Geosciences include earth, atmospheric, and ocean sciences.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-22.

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Bioinformatics

Changes under way in S&E education are readily apparent in bioinformatics. This field is increasingly interdisciplinary, as emerging technologies increase the amount of information that faculty and students across disciplines can gather, analyze, manipulate, and present.

In bioinformatics, powerful research resources are being accessed and used by undergraduate students and by researchers at the frontiers of their fields. The bioinformatics community offers Web-based material that students can access and manipulate. RasMol (http://www.umass.edu/microbio/rasmol), one of the most popular sites, has been accessed by more than 500,000 people in 115 countries. The Biology Workbench (http://workbench.sdsc.edu) contains information for both faculty and students and has held workshops to help people adapt their materials. A newly established resource in bioinformatics, aimed specifically at 2-year college users, illustrates how research at a commercial company, Geospiza, can serve as a base for education projects (http://www.geospiza.com/outreach/index).

mentoring efforts that have increased the participation of women and underrepresented minorities in S&E.[9]

The need to improve K–12 teacher preparation in S&E has been widely noted (see chapter 1 and National Commission on Mathematics and Science Teaching for the 21st Century 2000). The Presidential Award for Excellence in Mathematics and Science Teaching was established in 1983 to recognize outstanding teachers from each state. More recently, the Math and Science Partnership program, initiated in 2002, is designing ways to link institutions of higher education and local school districts to improve student achievement and teacher training. The sidebar "Meeting the Challenge of Teacher Preparation" notes some initial results of various programs that are under way to foster collaboration between S&E faculty and schools of education to improve teacher preparation. These efforts, although promising, are unlikely to solve this national need alone.

S&E Bachelor's Degrees by Sex

Women have outnumbered men in undergraduate education for several decades and earned 57 percent of all bachelor's degrees in 2000. Because men are more likely to choose S&E majors, however, they earned half of the total S&E bachelor's degrees in that year. About 37 percent of the bachelor's degrees earned by men were in S&E fields, compared with 28 percent for women. The female share was a slight increase from 25 percent in the late 1970s; the male share was a decline from 40 percent.

Within S&E, men and women tend to study different fields. Men earned most of the bachelor's degrees in engineering, computer science, and physical science fields (79, 72, and 59 percent, respectively). Women earned 77 percent of the bachelor's degrees in psychology, 59 percent in biological sciences, 54 percent in social sciences, and 48 percent in mathematics (appendix table 2-22 and figure 2-12).

S&E Bachelor's Degrees by Race/Ethnicity

In the past 2 decades, the racial/ethnic composition of those earning S&E bachelor's degrees changed, reflecting both population growth and increasing college attendance by members of minority groups. Between 1977 and 2000, the proportion of S&E degrees awarded to Asian/Pacific Islanders increased from 2 to 9 percent, and the proportion awarded to members of underrepresented minority groups grew from 9 to 16 percent (figure 2-13). In contrast, the proportion of S&E bachelor's degrees earned by white students declined from 87 percent in 1977 to 68 percent in 2000.[10] During the 1990s, the number of degrees earned by white students decreased in all S&E fields except computer, biological, and agricultural sciences and psychology.

In the 1990s, race/ethnicity trends in degrees earned differed by S&E field. American Asian/Pacific Islanders increased their share of degrees in all S&E fields (except

[9]For example, the Presidential Awards for Excellence in Science, Mathematics and Engineering Mentoring.

[10]Because of omission of an other or unknown race/ethnicity category, these percentages do not total 100 percent; see appendix table 2-23.

Meeting the Challenge of Teacher Preparation

Teacher preparation remains a responsibility of institutions of higher education, and some S&E faculty are becoming more involved in strengthening K–12 teacher preparation. A few of the innovative programs are described below. However, to keep pace with the increasing need for highly qualified teachers of science and mathematics, institutions of higher education would need to engage more S&E faculty in high-quality teacher preparation.

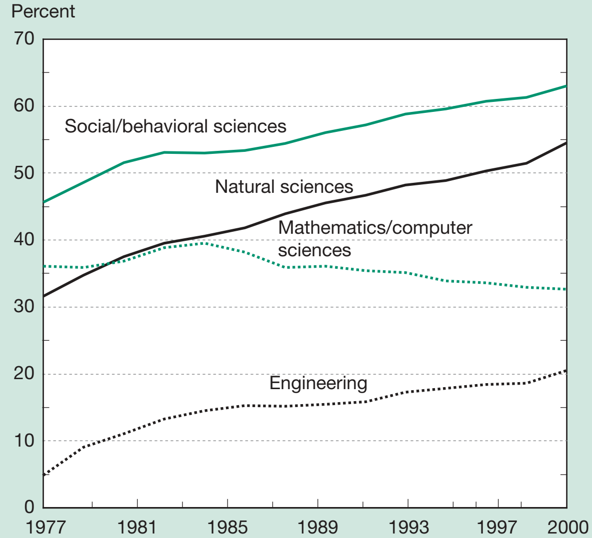
The National Science Foundation's Collaboratives for Excellence in Teacher Preparation program has stimulated reform of teacher preparation in 250 institutions of higher education, including 102 community colleges, through the collaborative efforts of more than 3,000 S&E and education faculty. More than 1,000 undergraduate courses have been revised or developed to improve the preparation of future teachers of science and mathematics by reflecting best practices in teaching.

RECRUIT is a program for recruiting, educating, certifying, and retaining underrepresented populations in teaching science and mathematics. The program prepares S&E graduates and midcareer scientists, mathematicians, and industry personnel for teaching careers in middle and high schools. Through collaboration among education faculty, S&E faculty, and K–12 teachers, the project provides an extended induction, support, and professional development period that continues 2 years beyond the initial 1-year training. Novice teachers participate in seminars taught by S&E and education faculty and receive support from mentor teachers. RECRUIT teachers are expected to affect 4,500 middle and high school students.

Enlist, Equip, and Empower (E^3) at Western Michigan University is designed to address the unique needs of middle school teachers for a conceptual understanding of general science principles across many disciplines. The project joins a science faculty member, science education faculty member, and middle school science teacher to work on improving the science knowledge and pedagogy of future middle school teachers.

mathematics), particularly computer, biological, and physical sciences and engineering. Blacks had slight increases in overall S&E degrees in the past 2 decades but had the strongest growth in biological and computer sciences, psychology, and engineering technologies. Hispanics had strong increases (but from a low base), especially in computer and biological sciences and psychology. American Indian/Alaskan Natives earned an increasing number of S&E degrees, but their total number of S&E bachelor's degrees in 2000 barely exceeded 2,600 (appendix table 2-23).

Figure 2-12
Female share of S&E bachelor's degrees, by selected fields: Selected years, 1977–2000



NOTES: Data for 1983 are estimated. Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-22.

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Despite considerable progress for underrepresented minority groups between 1990 and 2000 in earning bachelor's degrees, the gap in educational attainment between minorities and whites continues to be wide, especially in S&E fields. In 2000, the ratio of college degrees earned by members of these groups was 17.9 per 100 24-year-olds, about half that of whites. Their ratio for NS&E degrees was even lower (table 2-8). In contrast, Asian/Pacific Islanders have considerably higher-than-average achievement: 50.6 bachelor's degrees per 100 college-age population and 15.6 NS&E degrees per 100 college-age population in 2000.

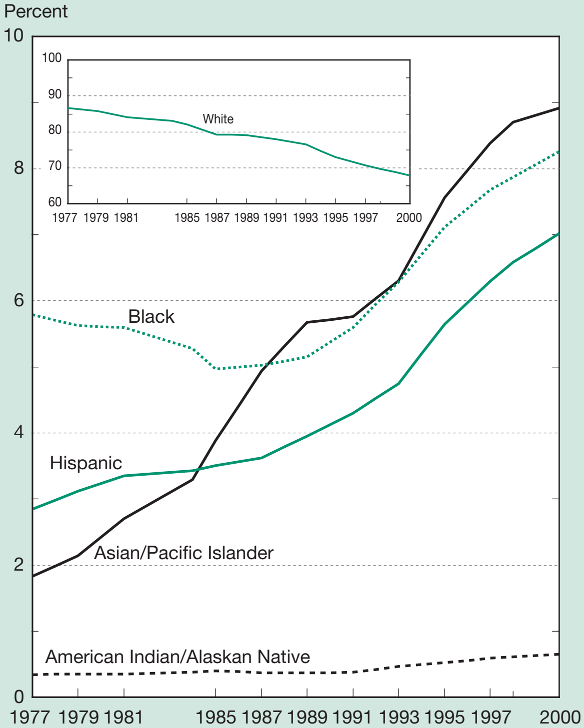
Bachelor's Degrees by Citizenship

Foreign students in the United States earned a small share (3.8 percent) of S&E degrees at the bachelor's level (appendix table 2-23). Trends in degrees earned by foreign students in the 1990s showed increases in the number of bachelor's degrees in social sciences and psychology, fluctuating and declining numbers in physical sciences and engineering, and relatively stable numbers in computer sciences, with an upturn in 2000. Foreign students in U.S. institutions earned approximately 7–8 percent of bachelor's degrees awarded in computer sciences and engineering (appendix table 2-23).

S&E Master's Degrees

Master's degrees in S&E fields increased from 63,800 in 1977 to 95,700 in 2000. The long-term growth peaked in 1995, then leveled off (except in computer sciences), and

Figure 2-13
Minority share of S&E bachelor's degrees, by race/ethnicity: Selected years, 1977–2000



SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-23.

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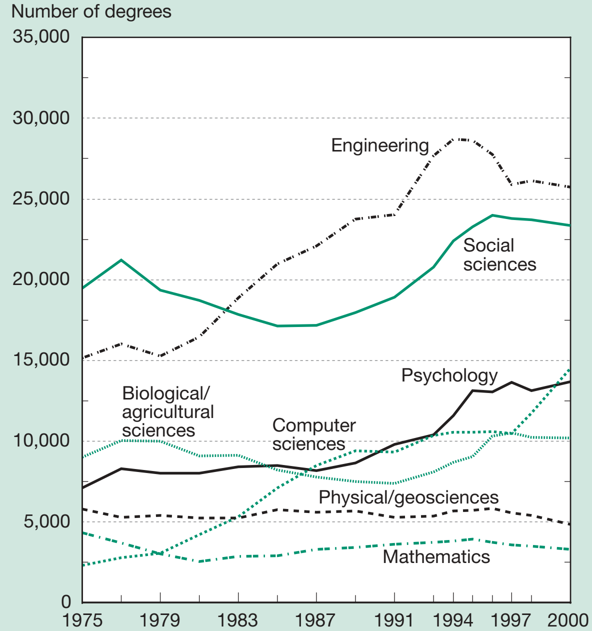
Figure 2-14
S&E master's degrees, by field: Selected years, 1975–2000



NOTE: Geosciences include earth, atmospheric, and ocean sciences.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-24.

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rose again in 2000. The four most common major fields accounted for most of the growth: engineering, social sciences, computer sciences, and psychology (figure 2-14). The mid-1990s decline in engineering master's degrees reflected enrollment declines for foreign students.

Research and doctorate-granting universities produced most of the master's degrees earned in engineering (87 percent), natural sciences (77 percent), and mathematics and computer sciences (68 percent) (figure 2-15).

Master's Degrees by Sex

Since 1975, the number of S&E master's degrees earned by women has tripled, rising from 13,800 to 41,500 in 2000 (figure 2-16). In addition to earning increasing numbers of degrees in both social sciences and psychology, which have historically had strong female representation, women showed strong growth in engineering and computer sciences (appendix table 2-24). In contrast, the number of master's degrees that men earned grew only marginally, from 49,400 in 1975 to 54,200 in 2000. The most popular S&E master's degrees for men remain in engineering, social sciences, and computer sciences.

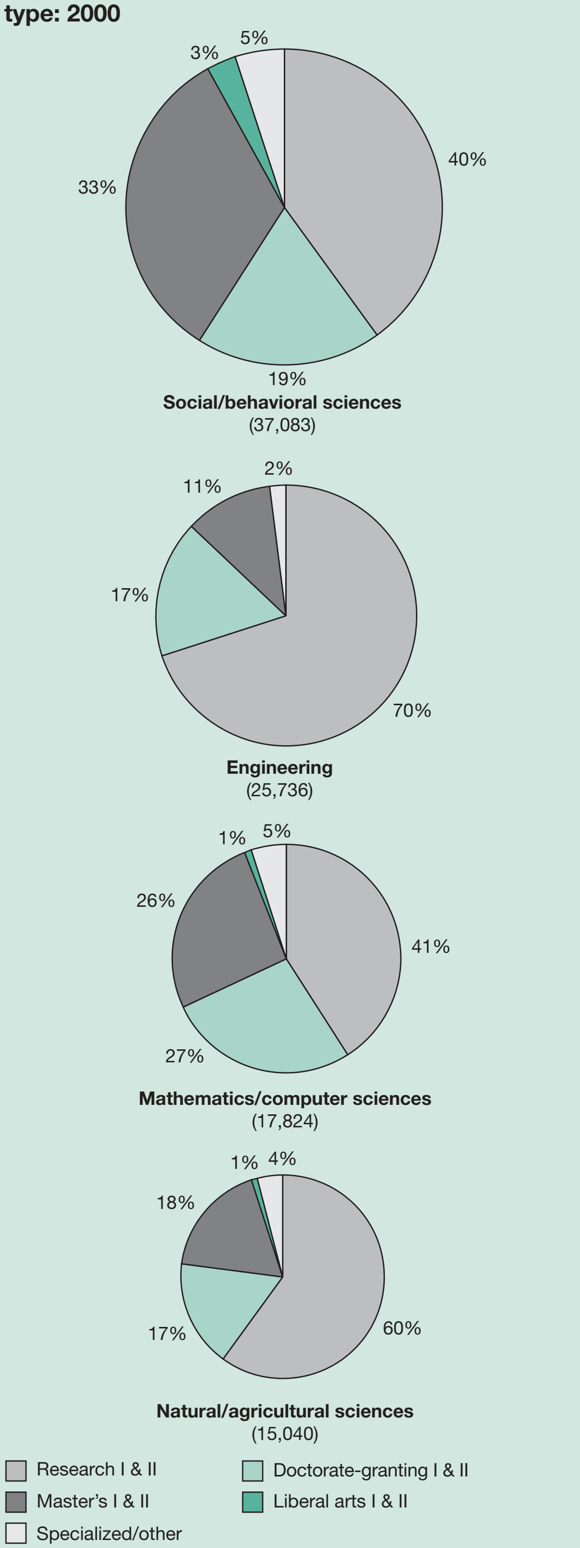
Master's Degrees by Race/Ethnicity

The proportion of S&E master's degrees earned by U.S. racial/ethnic minorities increased over the past 2 decades. Asian/Pacific Islanders accounted for 7.3 percent of master's degrees in 2000, up from 2.7 percent in 1977. Underrepresented minorities also registered gains, increasing from 5.9 to 10.1 percent during this period. The largest gains for underrepresented minorities were in engineering and physical sciences, both of which started from a very low base. Their percentage of master's degrees in engineering increased from 3.2 percent in 1977 to 6.1 percent in 2000; the corresponding figures in physical sciences were 3.4 and 6.3 percent (appendix table 2-25).

Master's Degrees by Citizenship

S&E master's degrees increased more rapidly among foreign students than among underrepresented minority groups or all U.S. citizens (figure 2-17), going from 7,800 in 1977 to 24,800 in 2000 (appendix table 2-25). This pushed their share of these degrees from 12 to 26 percent over this period. Foreign students make up a much higher proportion of S&E degree recipients at the master's level than at lower levels of the system. Their degrees are heavily concentrated in computer sciences (representing 45 percent of master's degrees awarded in that field) and engineering (38 percent of engineering degrees awarded) (appendix table 2-25). The increases among

Figure 2-15
S&E master's degrees, by field and institution type: 2000



NOTES: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences. Number of degrees in parentheses.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-3.

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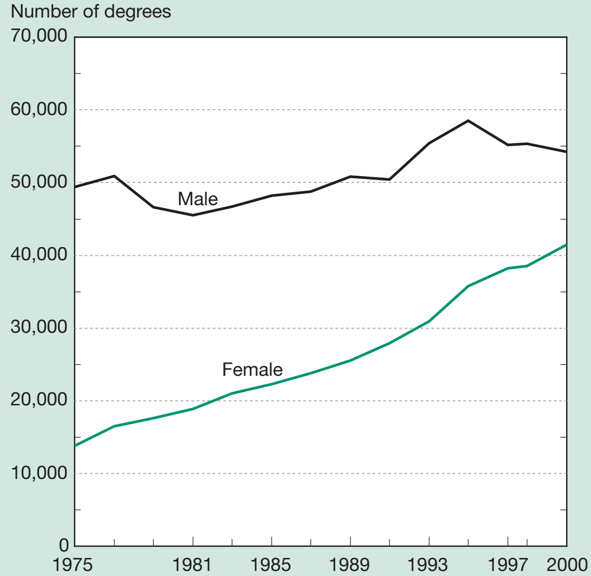
Figure 2-16
S&E master's degrees, by sex: Selected years, 1975–2000



SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-24.

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minorities and foreign students, along with a decline in the number of U.S. white students, led to a fall in the white majority share of S&E master's degrees from 79 percent in 1977 to 52 percent in 2000 (figure 2-18 and appendix table 2-25).[11]

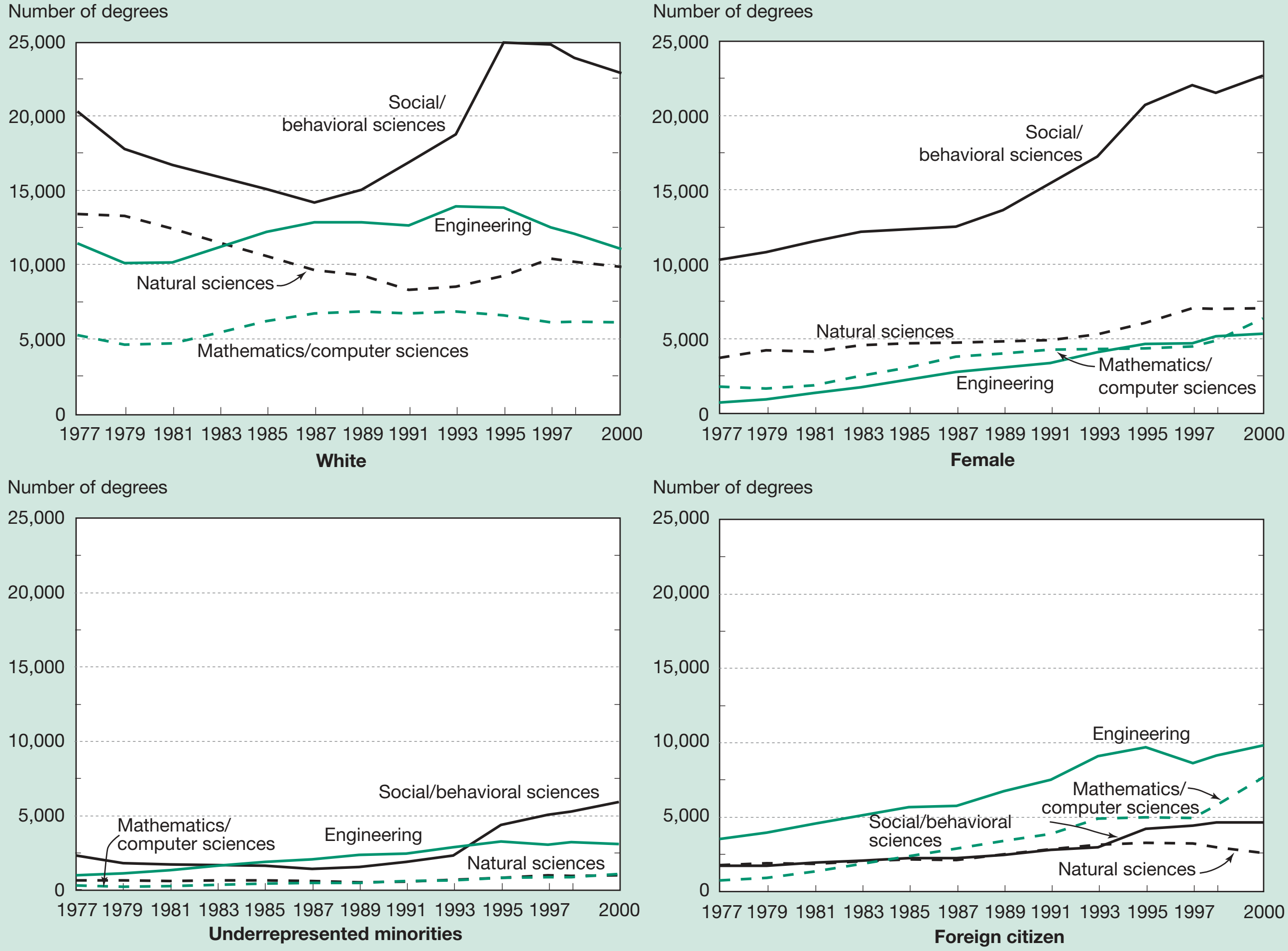
New Directions in Master's Programs

Many institutions are revisiting the graduate education programs they offer, perhaps in response to the suggestions of the Committee on Science, Engineering, and Public Policy (COSEPUP 1995) report to better prepare students for professional opportunities beyond research or to the uneven value the degree is accorded in different S&E fields. Although a master's degree in engineering is highly valued and an increasingly popular degree in the United States and other countries, a master's degree in some science fields implies a lack of advancement to the doctoral level.

Discussions in recent years have focused on creation of degree programs that validate useful advanced training below the doctoral level. These discussions have led to new directions in graduate education, manifested in new types of master's degree programs and the proliferation of professional certificate programs. The new master's programs often stress interdisciplinary training for work in emerging S&E fields. (See sidebar, "Developments in Master's Degree Programs.") Professional certificate programs at the graduate level are typically amenable to distance delivery

[11]An increase of 4 percentage points also occurred in the number of degree recipients with other or unknown race/ethnicity.

Figure 2-17
Master's degrees in S&E fields earned by selected groups: 1977–2000



NOTES: Data are estimated for 1983. Natural sciences include physics, chemistry, astronomy, and earth, atmospheric, ocean, biological, and agricultural sciences. Underrepresented minorities include black, Hispanic, and American Indian/Alaskan Native. White and underrepresented minorities include U.S. citizens and permanent residents. Foreign citizen includes temporary residents.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix tables 2-24 and 2-25.

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at corporate sites. These programs include a coherent set of courses for a specialty, such as engineering management.

S&E Doctoral Degrees

America's leaders in S&E research and education, especially in the academic sector, are drawn heavily from doctorate holders. As occurs at the bachelor's and master's degree levels, trends toward increasing numbers of S&E degree recipients and increasing the proportion of women, minorities, and foreign students occur at the doctoral level.

The number of S&E doctorates conferred annually by U.S. universities fluctuated around 18,000–19,000 through the mid-1980s, reached a peak of 28,800 in 1998, and declined to 27,100 in 2001. The rise through 1998 largely reflected growth in the number of foreign U.S. degree recipients. The largest degree increases were in engineering, biological sciences, and, to a lesser extent, social and computer sciences (figure 2-19). The post-1998 decline in earned doctorates reflects fewer degrees earned by both U.S. citizens and permanent residents (see "Doctoral Degrees by Citizenship").

Doctoral Degrees by Sex

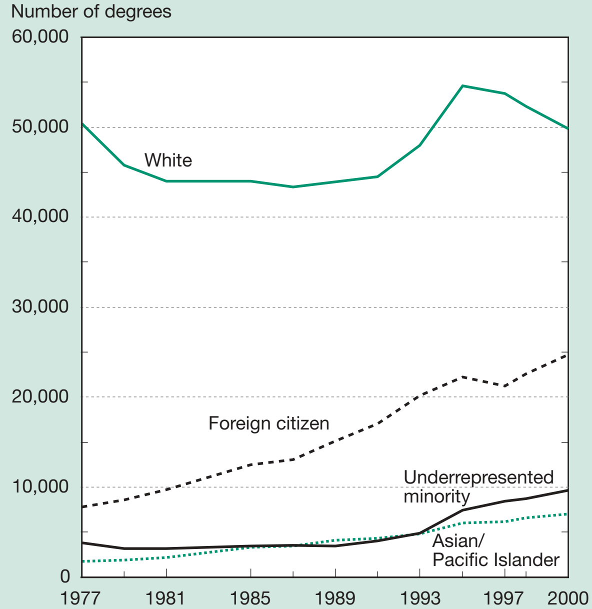
Among U.S. citizens, the proportion of S&E doctoral degrees earned by women has risen considerably in the past 3 decades, reaching a record 44 percent in 2001 (appendix table 2-26). Over this period, women made strong and uninterrupted gains, albeit from different bases, in all major field groups. However, as figure 2-20 shows, among total doctoral recipients, considerable differences by field continue, and the long-term trend of an increasing number of doctoral degrees earned by women may have begun to level off in 1999.

Developments in Master's Degree Programs

Attempts have recently been made to offer master's-level science education tailored to students interested in various nonacademic career options. These programs prepare students for positions in management, new product development, or consulting in the business, government, or nonprofit sectors. Many programs offer industrial internships or have courses with significant industry involvement, thereby building relationships between a university and the corporate sector. Some programs, such as the Master of Science in Financial Mathematics program at the University of Chicago, have been in existence for years, whereas others are new (Simmons 2003).

The Alfred P. Sloan Foundation is a primary sponsor of the current initiative in professional master's degree programs. By 2003, the Sloan Foundation will have funded 83 degree-granting programs at 35 research universities and 10 master's-focused institutions in fields from bioinformatics and computational linguistics to zoo and aquarium science management (http://www.sciencemasters.com). In fall 2002, 631 students were enrolled in Sloan Foundation-funded programs, with female students comprising 33 percent and underrepresented minority students comprising 8 percent of the student body.

Figure 2-18
S&E master's degrees, by race/ethnicity and citizenship: Selected years, 1977–2000



NOTES: Race/ethnicity groups include U.S. citizens and permanent residents. Underrepresented minority includes black, Hispanic, and American Indian/Alaskan Native. Foreign citizens include temporary residents only.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-25.

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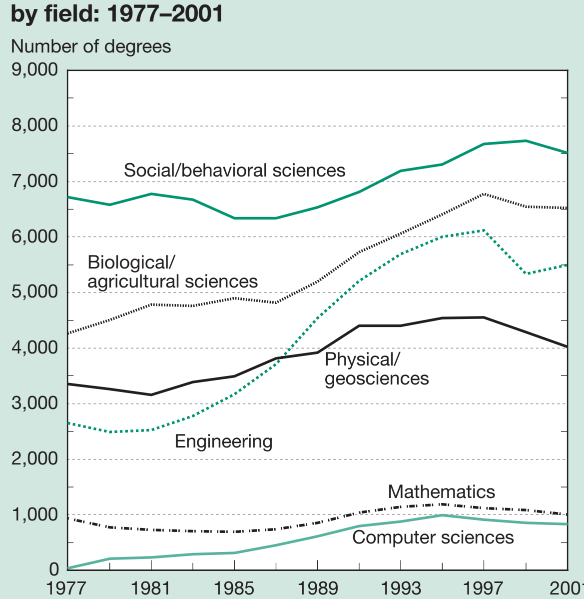
Doctoral Degrees by Race/Ethnicity

Although the proportion of S&E doctoral degrees earned by U.S. majority whites decreased in the past 2 decades, their number of S&E doctorates remained relatively stable, fluctuating between about 12,600 and 14,500 degrees annually. S&E doctoral degrees earned by whites reached 14,700 in 1995 and declined slightly each year since then, mainly in engineering, mathematics, and computer sciences (appendix table 2-27). The slight drop in these degrees may reflect good employment opportunities in high-technology industries during this period. The share of all S&E doctoral degrees earned by white U.S. citizens and permanent residents decreased from 71 percent in 1977 to 50 percent in 2001. As a share of S&E degrees awarded to U.S. citizens and permanent residents, it declined from 86 to 78 percent.

The proportion of doctoral degrees in S&E fields earned by U.S. underrepresented minorities increased slowly over the past 2 decades. Underrepresented minorities earned almost 1,550 S&E doctorates in 2001, accounting for 5.7 percent of the S&E doctoral degrees that year, up from 3.3 percent in 1977 (figure 2-21). Their share of degrees earned by U.S. citizens and permanent residents rose from 4 to 9 percent over the period. Gains by all underrepresented groups contributed to this rise; the number of degrees earned by blacks doubled, by Hispanics more than tripled, and by American Indian/Alaskan Natives nearly tripled. However, all three groups showed declines after 1999 or 2000.

Figure 2-19
S&E doctoral degrees earned in U.S. universities, by field: 1977–2001



NOTE: Geosciences include earth, atmospheric, and ocean sciences.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-26.

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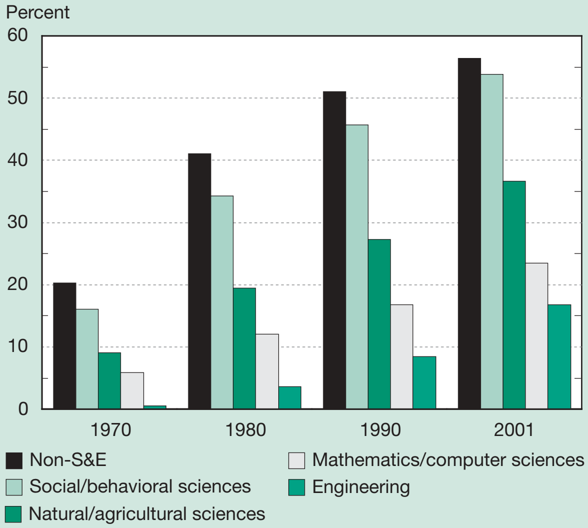
Figure 2-20
Doctoral degrees earned by women in U.S. institutions, by field: Selected years, 1970–2001



NOTE: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-26.

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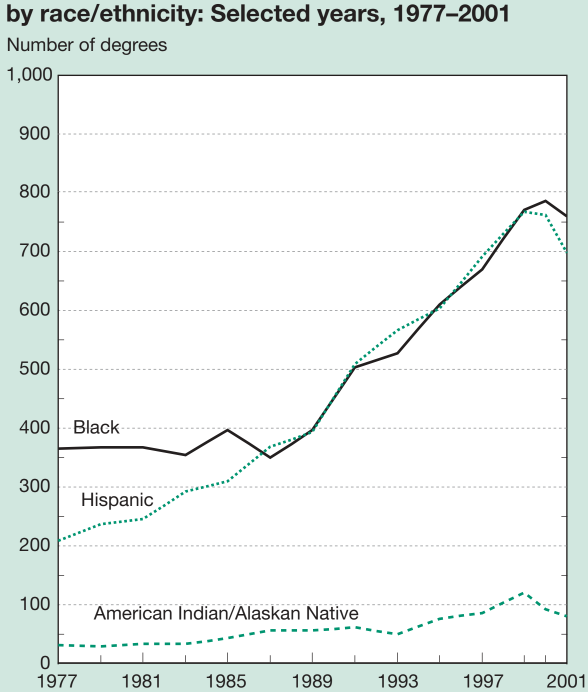
Figure 2-21
Underrepresented minority S&E doctoral degrees, by race/ethnicity: Selected years, 1977–2001



SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-27.

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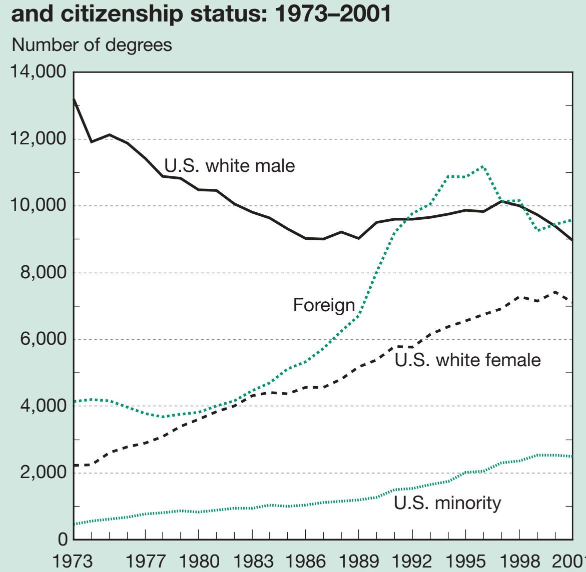
The largest gains were in social sciences and psychology. By 2001, the percentage of doctoral degrees earned by underrepresented minorities in psychology reached 11 percent, up from 5 percent in 1977; doctorates in social sciences increased from 5 percent in 1977 to 8 percent in 2001. Their number of engineering and computer science doctorates increased modestly throughout the 1990s but have decreased from highs reached in the late 1990s.

In the mid-1990s, doctoral degrees earned by Asian/Pacific Islanders who were citizens and permanent residents showed a steep increase. This increase mainly reflects the many Chinese doctoral students on temporary visas who shifted to permanent-resident status as a result of the 1992 Chinese Student Protection Act. The number of degrees earned by Asian/Pacific Islanders has since declined, representing a little more than 6 percent of the total in 2001.

Doctoral Degrees by Citizenship

Noncitizens account for most of the growth in U.S. S&E doctorates from the late 1980s through 2001 (figure 2-22). The number of degrees earned by U.S. citizens rose from 13,700 in 1985 to 17,300 in 1998 and then declined to 16,100 in 2001; non-U.S.-citizen degrees rose from 5,100 to 9,600 over the period, pushing the foreign share upward from about 26 to 35 percent by 2001. The number of S&E doctorates awarded to noncitizens peaked in 1996, leveled off and declined until 1999, and then began rising again. During the 1985–2001 period, foreign students at U.S. universities

Figure 2-22
U.S. S&E doctoral degrees, by sex, race/ethnicity, and citizenship status: 1973–2001



NOTES: Foreign includes permanent and temporary residents. Minority includes Asian/Pacific Islander, black, Hispanic, and American Indian/Alaskan Native. Degree recipients with unknown citizenship are omitted.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix tables 2-26, 2-27, and 2-28.

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earned close to 148,000 U.S. doctoral degrees in S&E fields (appendix table 2-28).

Foreign students earned a larger proportion of degrees at the doctoral level than at any other degree level, more than one-third of all S&E doctoral degrees awarded. Their proportion in some fields was considerably higher: in 2001, foreign students earned 49 percent of doctoral degrees in mathematics and computer sciences and 56 percent in engineering (figure 2-23). In particular subfields, foreign doctoral recipients were an even higher proportion of the total (e.g., 65 percent in electrical engineering) (NSF/SRS 2003b).

Doctoral Degrees by Time to Degree

Completing an S&E doctorate takes a long time, and time spent in school usually involves at least a short-term financial sacrifice. The time required to earn a degree affects the attractiveness of undertaking and persisting in doctoral study, which may, in turn, affect the number of doctorates and the quality of doctoral students.

The NSF Survey of Earned Doctorates tracks patterns and trends in the time it takes to earn an S&E doctorate. The survey measures time to degree in several ways. This section contains information about the median number of years between baccalaureate receipt and doctorate receipt and while registered in graduate school before doctorate completion (appendix table 2-29).

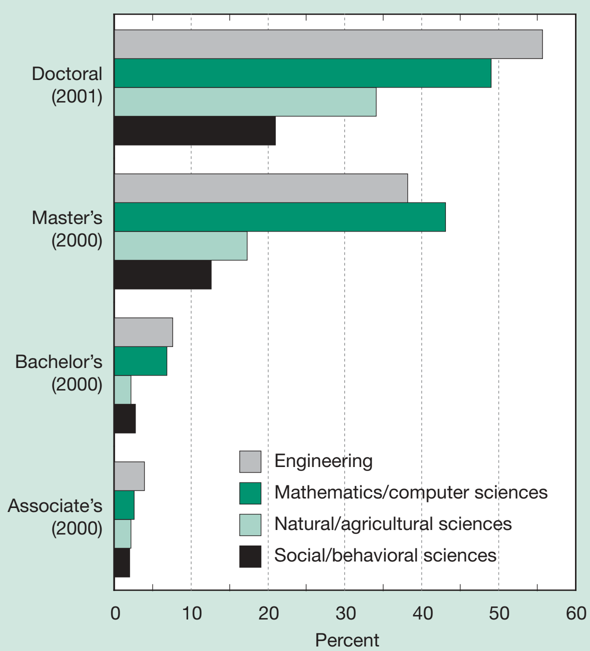
Data on the time from baccalaureate to doctorate show increases for all fields until the mid-1990s, followed by decreases thereafter. Physical sciences had the shortest and social sciences the longest time to degree. In the mid-1990s, the median time to degree completion was nearly 8 years in physical sciences, almost 9 years in engineering and biological sciences, and around 11 years in social sciences. By 2001, time to degree in each of these fields (as measured by elapsed time from baccalaureate) had shortened considerably (figure 2-24 and appendix table 2-29).

In registered time to degree, an increase occurred for all fields over time and persisted through the mid-1990s to 2000, with a slight shortening in several fields in 2001. Among S&E fields, in 2001, registered time to degree was shortest in physical sciences (6.4 years) and engineering (6.7 years) and longest in social sciences (8.2 years).

Postdocs

During the 1990s, increasing numbers of new doctorate holders received appointments as postdoctoral fellows. These positions were originally conceived as temporary appointments to obtain further specialized training after

Figure 2-23
Foreign student share of S&E degrees, by degree level and field: 2000 or 2001



NOTES: At the doctoral level, foreign students include permanent and temporary residents; other levels include only temporary residents. Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

SOURCES: U.S. Department of Education, Completions Survey; and National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix tables 2-21, 2-23, 2-25, and 2-28.

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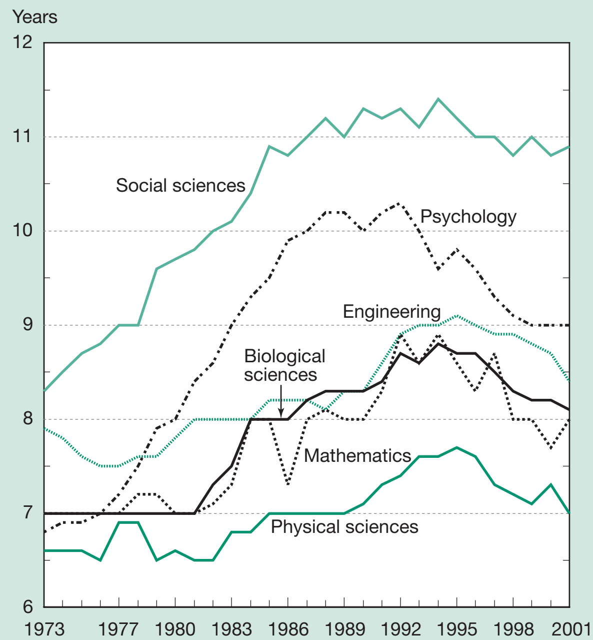
Figure 2-24
Time from bachelor's to S&E doctoral degree, by doctoral degree field: 1973–2001



NOTE: Values are median years between award of bachelor's degree and award of doctoral degree.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-29.

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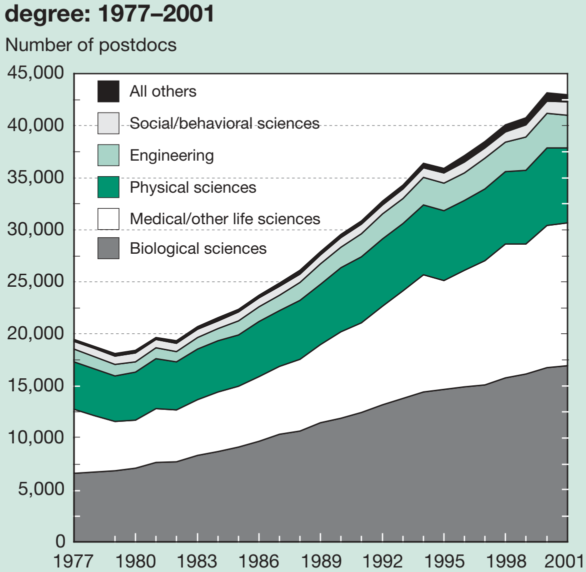
receiving a doctorate, but not all positions characterized as postdocs fit this description. Universities employ most postdocs, although not always under that title.

In 2001, there were almost 43,000 doctorate holders with science, engineering, or health postdoc appointments at U.S. universities, with approximately 30,000 of those in biological sciences and medical and other life sciences (figure 2-25) (NSF/SRS 2003a). More scientists have been taking such positions and, especially in life sciences, have been occupying them longer. According to data from NSF's Survey of Doctorate Recipients, before 1965, only 25 percent of all S&E doctorate holders ever had a postdoc appointment, and the average appointment lasted 20 months. In the cohort of students who graduated in 1989–91, however, 38 percent took postdoc appointments, with the average appointment lasting 29 months. These increases were most pronounced in biosciences (from 40 percent at 24 months in 1965 to 72 percent at 46 months in 1989–91) and physics (from 29 percent at 23 months in 1965 to 68 percent at 34 months in 1989–91) (chapter 3 and CPST 2003).

Data from the Survey of Graduate Students and Postdoctorates in Science and Engineering show that noncitizens account for much of the increase in the number of S&E postdocs (NSF/SRS 2003a). The number of foreign S&E postdocs (temporary residents) at U.S. universities increased from approximately 15,700 in 1991 to 24,600 in 2001. The number of U.S.-citizen and permanent-resident S&E postdocs at these institutions increased more modestly, from approximately 15,100 in 1991 to 18,400 in 2001 (figure 2-26 and appendix table 2-30).

Figure 2-25
Postdocs at U.S. universities, by field of doctoral degree: 1977–2001



NOTE: Data for 1978 are interpolated.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-30.

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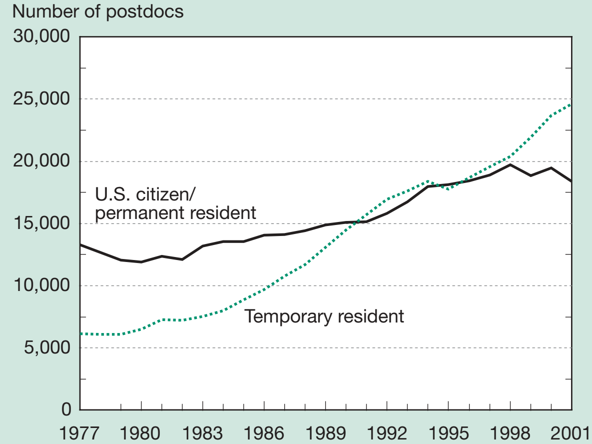
Figure 2-26
Postdocs at U.S. universities, by citizenship status: 1977–2001



NOTE: Data for 1978 are interpolated.

SOURCE: National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-30.

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The S&E community has become increasingly concerned about the well-being of postdocs and the effects that more and longer postdoc positions have on the attractiveness of S&E careers. Postdoc positions are often viewed as undesirable. Postdocs are paid less than other doctoral degree recipients; in 2001, the median salary for postdocs 1–3 years after completing their doctorate across all S&E fields was $33,000, whereas the median salary of nonpostdocs was $62,000 (CPST 2003). In addition, these positions often lack health insurance, retirement benefits, access to grievance procedures, pay raises, and annual reviews. The sidebar "Recent Developments Affecting Postdocs" describes some efforts to address the status of postdocs.

Foreign Doctoral Degree Recipients

Foreign recipients of U.S. doctoral degrees are an important part of the internationally mobile high-skilled labor force. When they return to their home countries or otherwise leave the United States after completing their degrees, they add to the stock of potential leaders in research and education, making those countries more competitive in S&E. Those who remain in the United States enhance the capability of U.S. S&E enterprise. In many cases, regardless of where they settle, their career trajectories foster ties between their countries of origin and the United States.

This section includes data on the places of origin of foreign doctorate recipients and on their stay rates in the United States after completing their degrees. The data are derived from the NSF Survey of Earned Doctorates, with special tabulations from 1985 to 2000.

Recent Developments Affecting Postdocs

The Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies produced a guide for postdocs, universities, funding organizations, and disciplinary societies, *Enhancing the Postdoctoral Experience for Scientists and Engineers* (COSEPUP 2000). Suggestions included developing institutional policies concerning compensation, status, recognition, evaluation, health insurance, and standards for postdocs. The report also suggested setting time limits for postdoc appointments, providing career guidance, and improving the transition from postdoc position to permanent employment.

The National Postdoctoral Association (NPA) was established in 2003 to improve the working conditions of postdocs. It has received funding from the Alfred P. Sloan Foundation and assistance from the American Association for the Advancement of Science (AAAS). Its threefold mission is to provide a voice for postdocs; build consensus concerning best practices; and collaborate with government bodies, funding agencies, and professional organizations.

Science's *Next Wave*, a weekly online publication from *Science* magazine and AAAS dealing with scientific training, career development, and the job market, has launched Postdoc Network, a forum of practical information for postdocs and their mentors. To collect consistent data to aid policymaking on postdocs, Sigma Xi, the scientific research society, is collaborating with NPA on a postdoc survey project, to be administered in spring 2004.

Both Stanford University and the University of California have begun tackling the concerns of postdocs on their campuses. Stanford University has adopted, and University of California schools are considering adopting, policies that share certain elements (Christopherson 2002 and University of California System 2002). These include a minimum annual salary ($36,000 at Stanford and $29,000 at University of California schools); medical benefits; a 5-year limit for postdoc positions, after which postdocs may be hired in staff positions; a grievance policy; and a leave policy. Stanford is publishing a best-practices manual for postdocs and their mentors and is expanding its career center to help postdocs in their transition to permanent employment (Sreenivasan 2003).

Major Countries/Economies of Origin

Students from 11 major foreign countries/economies and three regional groupings together accounted for nearly 70 percent of all foreign recipients of U.S. S&E doctorates from 1985 to 2000. The major Asian countries/economies sending doctoral students to the United States have been China, Taiwan, India, and South Korea, in that order. Major European countries of origin have been Germany, Greece, the United Kingdom, Italy, and France. Data on regional groupings of other Western European, Scandinavian, and Eastern European countries are also given, as are data for Mexico and Canada. Because students from Asia represent such a large proportion of foreign S&E doctoral degree recipients at U.S. universities, trends in their earned degrees are examined separately.

Asia

U.S. S&E doctorates earned by Asian students increased from the mid-1980s to the mid- to late 1990s, followed by a decline. Most of the degrees were in engineering and biological and physical sciences. From 1985 to 2000, students from the four Asian countries/economies (China, Taiwan, India, and South Korea) earned more than 50 percent of S&E doctoral degrees awarded to foreign students in the United States (68,500 of 138,000), four times more than students from Europe (16,000).

From 1985 to 2000, students from the People's Republic of China earned, cumulatively, more than 26,500 S&E doctoral degrees at U.S. universities, mainly in biological and physical sciences and engineering (table 2-9). The number of S&E doctorates earned by Chinese students increased from 138 in 1985 to almost 3,000 in 1996. After this peak year, their number of doctorates from U.S. institutions declined and leveled off until 1999 and then increased slightly in 2000 and 2001.[12]

Students from Taiwan received the second-largest number of S&E doctorates at U.S. universities. Between 1985 and 2000, Taiwanese students earned almost 15,500 S&E doctoral degrees, mainly in engineering and biological and physical sciences (table 2-9). Taiwan was an early user of U.S. doctoral education. In 1985, students from Taiwan earned more U.S. S&E doctoral degrees than students from India and China combined. The Taiwanese number of degrees increased rapidly for almost a decade, from 746 in 1985 to 1,300 at their peak in 1994. However, as Taiwanese universities increased their capacity for advanced S&E education in the 1990s, S&E doctorates earned from U.S. universities by Taiwanese students declined from 1,300 in 1994 to 669 in 2000.[13]

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[12]The number of S&E doctoral degrees earned by Chinese students within Chinese universities continued to increase throughout the decade, from 1,069 in 1990 to 8,153 in 2001 (National Science Board 2002 and China's National Research Center for Science and Technology for Development, special tabulations, 2003).

[13]A current science and technology policy debate in Taiwan is focused on whether to encourage more Taiwanese to study at U.S. universities for the subsequent benefits of networking between Taiwanese and U.S. scientists and engineers.

Table 2-9
Asian recipients of U.S. S&E doctorates by field and country/economy of origin: 1985–2000

Field	All Asian recipients	China	Taiwan	India	South Korea
All fields	80,310	28,698	18,508	16,029	17,075
S&E	68,550	26,534	15,487	13,274	13,255
Physical sciences	11,987	6,356	1,923	1,856	1,852
Earth, atmospheric, and ocean sciences	1,731	972	327	180	252
Mathematics	3,585	1,954	614	438	579
Computer/information sciences	3,221	673	839	1,178	531
Engineering	25,923	7,207	7,518	6,146	5,052
Biological sciences	12,251	6,790	2,175	1,766	1,520
Agricultural sciences	2,333	901	601	316	515
Psychology/social sciences	7,519	1,681	1,490	1,394	2,954
Non-S&E[a]	11,760	2,164	3,021	2,755	3,820

[a]Includes medical and other life sciences.

NOTE: Foreign doctorate recipients include permanent and temporary residents.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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Table 2-10
European and North American recipients of U.S. S&E doctorates, by field and region/country of origin: 1985–2000

	Europe[a]				North America		
Field	Total	Western	Scandinavia	Eastern	Total	Mexico	Canada
All fields	21,525	15,840	1,386	4,299	9,423	2,501	6,922
S&E	16,123	11,277	1,023	3,823	6,075	2,077	3,998
Physical sciences	3,281	2,040	163	1,078	725	187	538
Earth, atmospheric, and ocean sciences	641	459	62	120	241	93	148
Mathematics	1,720	924	81	715	337	123	214
Computer/information sciences	756	520	57	179	172	52	120
Engineering	3,484	2,461	198	825	1,077	458	619
Biological sciences	2,347	1,690	136	521	1,244	381	863
Agricultural sciences	534	420	48	66	575	388	187
Psychology/social sciences	3,360	2,763	278	319	1,704	395	1,309
Non-S&E[b]	5,402	4,563	363	476	3,348	424	2,924

[a]See figure 2-28 for countries included in Western Europe, Scandinavia, and Eastern Europe.
[b]Includes medical and other life sciences.

NOTE: Foreign doctorate recipients include permanent and temporary residents.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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Indian students earned more than 13,000 S&E doctoral degrees at U.S. universities over the period, mainly in engineering and physical and biological sciences. They also earned by far the largest number of U.S. doctoral degrees awarded to any foreign group in computer and information sciences (table 2-9). The decade-long increase in U.S. S&E doctorates earned by Indian students ended in 1996, followed by 4 years of decline. The decline was particularly marked in engineering (57 percent) and computer sciences (50 percent).[14]

[14]Increasing employment opportunities in IT and software engineering (in the United States and India) may have lessened the incentive for completing a doctoral degree in these fields.

South Korean students earned more than 13,000 U.S. S&E doctorates, mainly in engineering, physical sciences, and psychology and social sciences (table 2-9). Their number of S&E doctoral degrees increased from 300 in 1985 to more than 1,000 in 1990, fluctuated around 1,000 for the first half of the 1990s, and then declined and leveled off at about 700 by the end of the decade.

Europe

European students earned less than one-fourth the number of S&E doctorates earned by Asian students and tended to focus more on social sciences and psychology than their Asian counterparts (table 2-10).

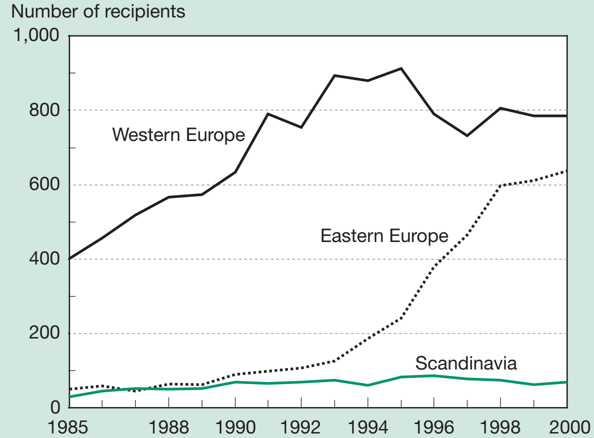
Western European countries whose students earned the most U.S. S&E doctorates from 1985 to 2000 were Germany, Greece, the United Kingdom, Italy, and France, in that order. From 1985 to 1993, Greece and the United Kingdom were the primary European countries of origin; thereafter, their numbers of doctoral degree recipients declined and leveled off. Germany was the only major Western European country whose students earned an increasing number of U.S. S&E doctorates throughout the 1990s (figure 2-27).[15] Scandinavians received fewer U.S. doctorates than students from the other European regions, with a field distribution roughly similar to that for other Western Europeans.

The number of Eastern European students earning S&E doctorates at U.S. universities increased from fewer than 100 in 1990 to more than 600 in 2000 (figure 2-28). A higher proportion of Eastern European (89 percent) than Western European (71 percent) recipients of U.S. doctorates were in S&E fields. Within S&E, Western Europeans were more likely to study psychology and social sciences and engineering, and Eastern Europeans tended to study physical sciences, engineering, and mathematics (table 2-10).

North America

The Canadian and Mexican shares of U.S. S&E doctoral degrees were small compared with those from Asia and Europe The number of degrees earned by Canadian students increased rapidly in the second half of the 1980s, from about 150 in 1985 to more than 300 in 1991, and then remained relatively stable in the 1990s. Fifty-eight percent of Canadian doctoral degree students in U.S. universities earned S&E doctorates, mainly in psychology and social and biological sciences (figure 2-29 and table 2-10). Mexican doctoral students in U.S. universities are more concentrated in S&E fields than are Canadian students. Eighty-three percent of the doctoral degrees earned by Mexican students at U.S. universities were in S&E fields, mainly engineering, psychology and social sciences, and biological and agricultural sciences. The number of doctoral degree recipients from Mexico fluctuated and increased slowly throughout the period, from 100 degrees earned in 1985 to more than 200 in 2000.

Figure 2-28
U.S. S&E doctoral degree recipients from Europe, by region: 1985–2000



NOTES: Degree recipients include permanent and temporary residents. Western Europe includes Andorra, Austria, Belgium, France, Germany, Gibraltar, Greece, Ireland, Italy, Luxembourg, Malta, Monaco, Netherlands, Portugal, Spain, and Switzerland. Eastern Europe includes Albania, Bulgaria, Czech Republic, Slovakia, Hungary, Poland, Romania, Russia, Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgystan, Latvia, Moldova, Tadjikistan, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia, Bosnia-Herzogovina, Croatia, Macedonia, and Serbia-Montenegro. Scandinavia includes Denmark, Finland, Iceland, Norway, and Sweden.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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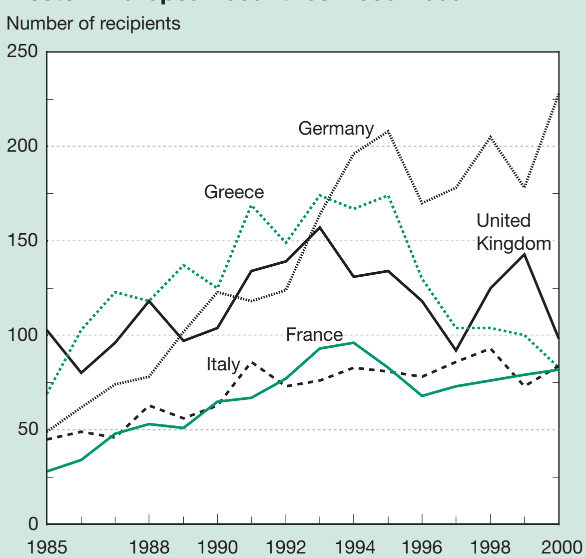
Figure 2-27
U.S. S&E doctoral degree recipients from selected Western European countries: 1985–2000



NOTE: Degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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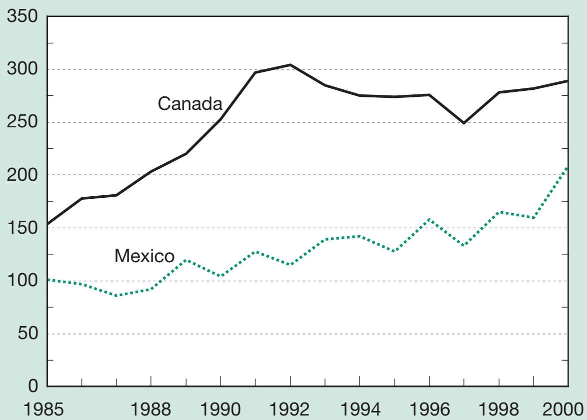
Stay Rates

Almost 30 percent of the actively employed S&E doctorate holders in the United States are foreign born, as are many postdocs. Most of those working in the United States (excluding postdocs) obtained their doctorates from U.S. universities. Stay rates, based on stated plans at receipt of doctorate, indicate how much the United States relies on inflow of doctorate holders from different countries and whether working in the United States remains an attractive option for foreign students who obtain U.S. doctorates. In chapter 3, we report an analysis using a stay-rate measure

[15]Germany is also the top country of origin of foreign doctoral degree recipients at U.K. universities (National Science Board 2002). German doctoral programs are long, and students may prefer the shorter U.K. and U.S. degree programs.

Figure 2-29
U.S. S&E doctoral degree recipients from Canada and Mexico: 1985–2000



NOTE: Doctoral degree recipients include permanent and temporary residents.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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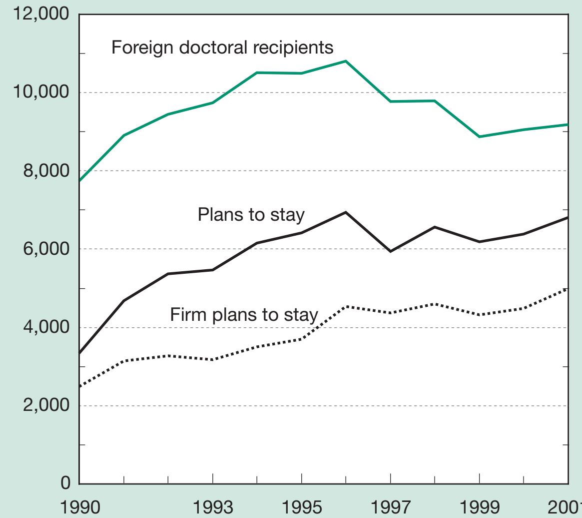
Figure 2-30
Plans of foreign recipients of U.S. S&E doctorates to stay in United States: 1990–2001



NOTES: Foreign doctoral recipients include permanent and temporary residents. Appendix table 2-31 includes plans to stay by place of origin and field of study in 3-year increments.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003. See appendix table 2-31.

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based on examination of Social Security records several years after the doctorate.

Historically, approximately 50 percent of foreign students who earned S&E degrees at universities in the United States reported that they planned to stay in the United States, and a smaller proportion said they had firm offers to do so (NSF/SRS 1998). However, these percentages increased significantly in the 1990s. In the 1990–93 period, for example, of the foreign S&E doctoral degree recipients who reported their plans, 63 percent planned to remain in the United States after receiving their degree, and 41 percent had firm offers. By the 1998–2001 period, 76 percent of foreign doctoral degree recipients in S&E fields with known plans intended to stay in the United States, and 54 percent accepted firm offers to do so (appendix table 2-31). Although the number of S&E doctoral degrees earned by foreign students declined after 1996, the number of students who had firm plans to remain in the United States declined only slightly from its 1996 peak. Each year from 1996 to 2000, around 4,500 foreign doctoral degree recipients had firm offers to remain in the United States at the time of degree conferral, with a slight increase in 2001 (figure 2-30).

Stay rates vary by place of origin. From 1985 to 2000, most U.S. S&E doctoral degree recipients from China and India planned to remain in the United States for further study and employment. In 2001, 70 and 77 percent, respectively, reported accepting firm offers for employment or postdoctoral research in the United States (figure 2-31).

Recipients from South Korea and Taiwan are less likely to stay in the United States. Over the 1985–2000 period, only 26 percent of South Koreans and 31 percent of Taiwanese reported accepting firm offers to remain in the United States. Both the number of S&E students from these Asian economies and the number who intended to stay in the United States after receipt of their doctoral degree fell in the 1990s. This decline may be because Taiwan and South Korea have expanded and improved their advanced S&E programs and created R&D institutions that offer more attractive S&T careers for their expatriate scientists and engineers. Still, by 2001, about 50 percent of their new U.S. doctorate holders reported accepting U.S. appointments.

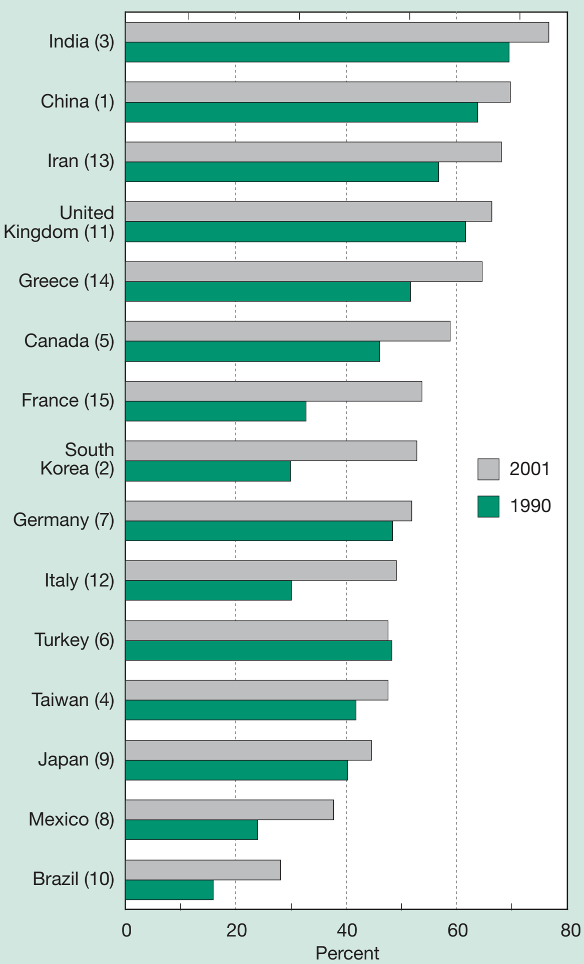
Historically, a relatively high percentage of U.S. S&E doctoral degree recipients from the United Kingdom planned to stay in the United States, whereas France and Italy had small percentages compared with other Western European countries (NSF/SRS 1998). However, by 2001, 50 percent or more of the doctoral degree students from these countries had firm plans to stay, as did those from Germany (figure 2-31). Stay rates for Eastern European doctoral degree recipients were high, exceeded only by those for India (appendix table 2-31).

The percentage of doctoral degree students who had firm plans to stay in the United States in 2001 was higher for Canada (58 percent) than for Mexico (38 percent), which has one of the lowest stay rates of all the major countries of origin of foreign U.S. doctoral degree recipients (figure 2-31).[16]

[16]The Mexican government's scholarship-loan programs erase the debt for those who enter public research universities on their return from overseas study (National Council for Science and Technology 2001).

A study of U.S. doctoral degree recipients from foreign countries explored the factors affecting the decision to stay in the United States (Gupta, Nerad, and Cerny 2003). The study cited numerous factors, stressing the strength of preexisting ties to the recipients' home countries. Among the doctorate holders studied, the principal source of funding was related to their likelihood of staying in the United States: those who stayed were more likely to have been funded primarily by RAs and TAs, and those who returned to their home countries were more likely to have relied on funding from their national government or their employer.

Figure 2-31
Short-term stay rates of foreign recipients of U.S. S&E doctorates, by place of origin: 1990 and 2001



NOTES: Numbers in parentheses rank the top 15 places of origin of foreign recipients of U.S. S&E doctorates conferred in 2001. Short-term stay rates count those with firm commitments of postaward employment or postdoctoral employment. Longer-term stay rates may differ. Appendix table 2-31 includes plans to stay by place of origin and field of study in 3-year increments.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

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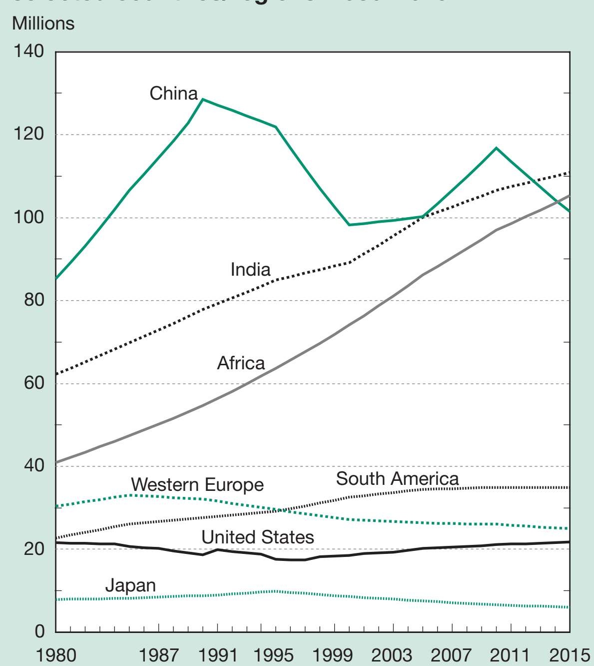
International S&E Higher Education

Excellence in S&E higher education helps a country to be technologically innovative and economically competitive (Greenspan 2000). Recognizing this, other countries are seeking to improve their relative standing in this area. This section places data on U.S. S&E higher education in an international comparative perspective. It presents available data on bachelor's (first university) degrees, including selected disaggregations by field and sex. It also compares participation rates in S&E degrees in different countries, including data on foreign student enrollment and degrees for selected countries.

The college-age cohort decreased in all major industrialized countries either in the 1980s or 1990s, although for different durations and to varying degrees (appendix table 2-32). To produce enough S&E graduates for increasingly knowledge-intensive societies, industrialized countries have sought to enroll a higher proportion of their citizens in higher education, train a higher proportion in S&E, and recruit S&E students from other countries, especially in the developing world. For example, China and India each has more than 90 million people of college age and is a major country of origin for foreign graduate students in the United States. Figure 2-32 shows that by 2015, the college-age cohort in Africa will surpass that of China.

Figure 2-32
Trends in population of 20–24-year-olds, by selected countries/regions: 1980–2015



SOURCES: United Nations Population Division, *World Population Prospects: The 2002 Revision*; and U.S. Bureau of the Census, Population Division, *Projections of the Resident Population by Age, Sex, Race, and Hispanic Origin: 1999 to 2100*. See appendix table 2-32.

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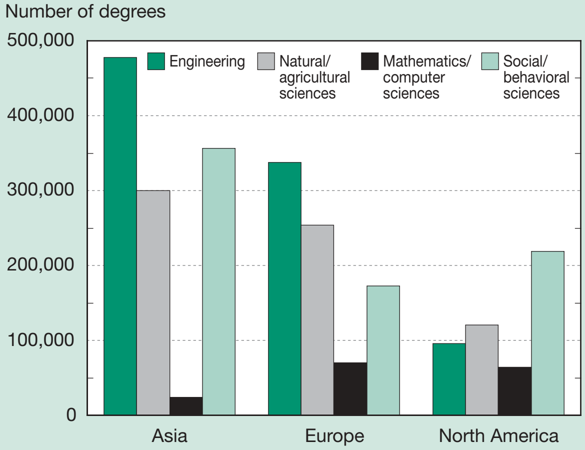
International Degree Trends

The availability and quality of international degree data vary. Major efforts of international statistical agencies have been under way for more than a decade to improve collection, reporting, and dissemination of these data.[17]

First University Degrees in S&E Fields

In 2000, more than 7.4 million students worldwide earned a first university degree,[18] and about 2.8 million of the degrees were in S&E fields: more than 1 million in engineering, almost 850,000 in social and behavioral sciences, and almost 1 million in mathematics and natural, agricultural, and computer sciences combined (appendix table 2-33). These worldwide totals only include countries for which data are readily available (primarily the Asian, European, and American regions) and are therefore an underestimation. Asian universities accounted for almost 1.2 million of the world's S&E degrees in 2000, with almost 480,000 degrees in engineering (figure 2-33). Students across Europe (including Eastern Europe and Russia) earned more than 830,000 S&E degrees, and students in North America earned more than 500,000.

Figure 2-33
First university S&E degrees in Asia, Europe, and North America, by field: 2000



NOTE: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

SOURCES: Organization for Economic Co-operation and Development, *Education at a Glance 2002*; United Nations Educational, Scientific, and Cultural Organization (UNESCO), UNESCO Institute for Statistics database; and national sources. See appendix table 2-33 for countries/economies included in each region.

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Although the United States has historically been a world leader in offering broad access to higher education, many other countries now provide comparable access. The ratio of bachelor's degrees earned in the United States to the population of the college-age cohort remained relatively high at 33.8 per 100 in 2000 (appendix table 2-33). However, nine other countries also provided a college education to at least one-third of their college-age population.

A workforce trained in NS&E is indispensable to a modern economy. The proportion of the college-age population that earned degrees in NS&E fields was substantially larger in more than 16 countries in Asia and Europe than in the United States in 2000. The United States achieved a ratio of 5.7 per 100 after several decades of hovering between 4 and 5. Other countries/economies have recorded bigger increases: South Korea and Taiwan increased their ratios from just over 2 per 100 in 1975 to 11 per 100 in 2000–01. At the same time, several European countries have doubled and tripled their ratios, reaching figures between 8 and 11 per 100 (figure 2-34).

In several emerging Asian countries/economies, the proportion of first university degrees earned in S&E was higher than in the United States. For the past 3 decades, S&E degrees have made up about one-third of U.S. bachelor's degrees. The corresponding figures were considerably higher for China (59 percent in 2001), South Korea (46 percent in 2000), and Japan (66 percent in 2001) (appendix table 2-33).

In engineering fields, the contrast between the United States and other relatively advanced regions becomes sharper. Compared with Asia and Europe, the United States has a relatively low proportion of S&E bachelor's degrees in engineering. In 2000, students in Asia and Europe earned 40–41 percent of their first university S&E degrees in engineering. In contrast, students in the United States earned about 15 percent of their S&E bachelor's degrees in engineering fields (appendix table 2-33).

Long-term trend data on first university S&E degrees, available for selected countries, show strong growth in the 1990s in China and Japan (with a leveling off in 2000–01) and steady growth in South Korea, the United Kingdom, and the United States (figure 2-35). In the late 1990s, first university S&E degrees (of long duration) declined in Germany.[19] Germany had a sharp decline in engineering degrees, from 16,000 in 1998 to 9,000 in 2001 (Grote 2000 and appendix table 2-34).

International Comparison of Participation Rates by Sex

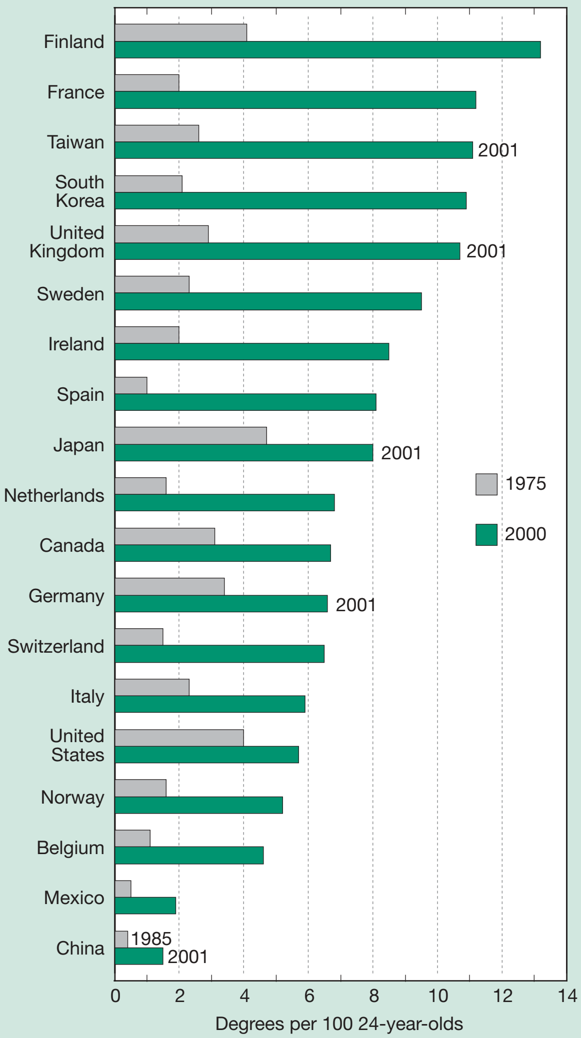
Among large Western countries for which first university degree data are available by sex, France, the United Kingdom, Spain, Canada, and the United States had relatively

[17]Organisation for Economic Co-operation and Development, *Education at a Glance,* 2000, includes data on member countries; UNESCO Institute for Statistics (UIS) is giving within-country statistical training to expand the number of developing countries providing recent reliable data and validating the reported data within UIS.

[18]A first university degree refers to completion of a terminal undergraduate degree program. These degrees are classified as level 5A in the International Standard Classification of Education (ISCED 97), although individual countries use different names for the first terminal degree; for example, *laureata* in Italy, *diplome* in Germany, *maîtrise* in France, and *bachelor's degree* in the United States and Asian countries.

[19]The German data in figure 2-35 include only the long first university degree, which is required for further study. In 2001, an additional 40,000 S&E degrees were earned within *Fachhochschulen*, which are 3–5-year programs (appendix table 2-34).

Figure 2-34
Ratio of first university NS&E degrees to 24-year-old population, by country/economy: 1975 and 2000 or most recent year



NS&E natural sciences and engineering

NOTES: NS&E includes natural (physical, biological, earth, atmospheric, and ocean sciences), agricultural, and computer sciences; mathematics; and engineering. The ratio is the number of earned degrees in these fields per 100 24-year-olds.

SOURCES: Organization for Economic Co-operation and Development, *Education at a Glance 2002;* and national sources. See appendix table 2-33 for most recent data.

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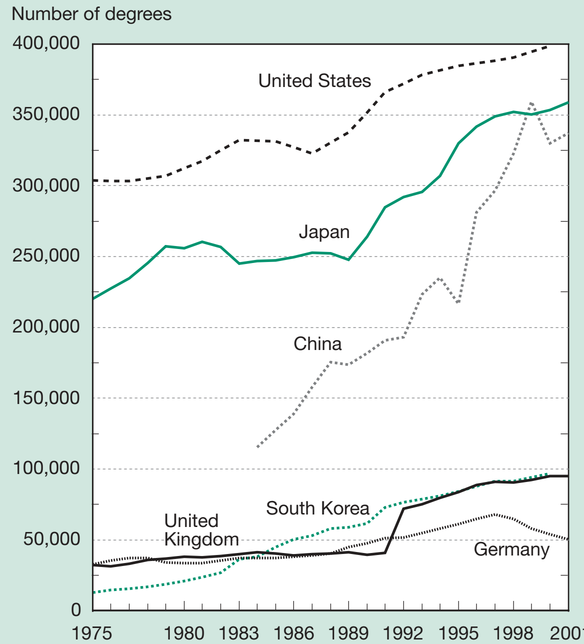
Figure 2-35
S&E first university degrees, by selected countries: 1975–2001



NOTE: German degrees include only long university degrees required for further study.

SOURCES: China—National Research Center for Science and Technology for Development, special tabulations; Japan—Government of Japan, Monbusho Survey of Education; South Korea—Ministry of Education, *Statistical Yearbook of Education,* and Organisation for Economic Co-operation and Development, *Education at a Glance 2002;* United Kingdom—Higher Education Statistics Agency, special tabulations; Germany—Federal Statistical Office, *Prüfungen an Hochschulen;* and United States—National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov. See appendix table 2-34.

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high participation rates for both men and women. In 2000, the ratio of female-earned first university degrees to the female 24-year-old population was about the same in France and the United Kingdom (41 per 100), Spain and the United States (39 per 100), and Canada (38 per 100). Women in the United Kingdom and France also had high participation rates in earned NS&E bachelor's degrees. In 2000, the ratio of NS&E degrees earned by women to the female 24-year-old population in the United Kingdom and France was 8 per 100. In France, this rate was more than half the rate for men.

In the United States, participation rates in NS&E degrees were 4.5 per 100 for women and 6.8 per 100 for men (appendix table 2-35).

In Japan, Taiwan, and South Korea, women earn first university degrees at a rate similar to that in many European countries. However, women have high participation rates in NS&E only in South Korea and Taiwan. In 2000–01, the ratio of female-earned degrees in these fields to the female 24-year-old population was 7.4 per 100 in South Korea and 5.0 per 100 in Taiwan, higher than the participation rate of women in Japan, Germany, or the United States. Among reporting countries, women earned the highest proportion of their S&E degrees in natural and social sciences (appendix table 2-35).

International Comparison of Doctoral Degrees in S&E Fields

The proportion of S&E doctoral degrees earned outside the United States appears to be increasing. Of the 114,000 S&E doctoral degrees earned worldwide in 2000, 89,000 were earned outside the United States (appendix table 2-36). Figure 2-36 shows the breakdown of S&E doctoral degrees by major region and selected fields.

The proportion of S&E doctoral degrees earned by women is increasing in several world regions. In 2000, women earned more than 35 percent of S&E doctorates in several countries of Western Europe (Finland, France, Spain, Ireland, and Italy) and Eastern Europe (Bulgaria, Croatia, and Georgia). In the same year, women earned more than 40 percent of the doctoral degrees awarded in natural sciences in these countries (appendix table 2-37).

For most of the past 2 decades, momentum in NS&E doctoral degree programs has been strong in the United States and some Asian and European countries. Japan's 1993 national science policy to increase basic research for innovation led to a doubling of university research funding by 1997 and significant expansion of university doctoral programs. There was even stronger growth in China, and, by 2001, China was the largest producer of NS&E doctoral degrees in the Asian region. However, in the late 1990s, NS&E doctoral degrees leveled off in Germany and declined in the United States (figure 2-37). Figure 2-38 shows trends in NS&E doctoral degrees by region.

International Student Mobility

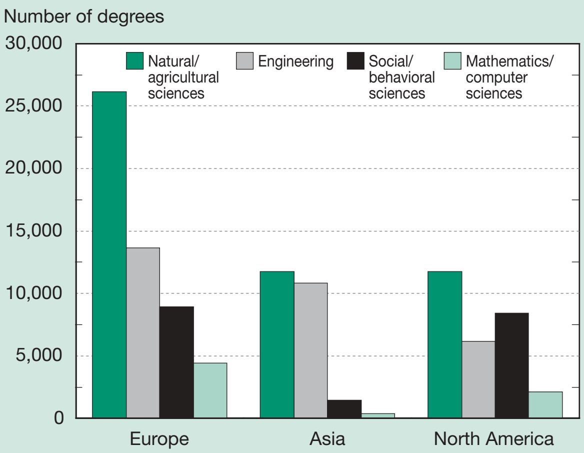
The 1990s witnessed a worldwide increase in the number of students going abroad for higher education study to the well-established destinations of the United States, the United Kingdom, and France. However, other countries, including Japan, Canada, and Germany, also expanded their enrollment of foreign S&E graduate students.

Foreign Enrollment in S&E in Selected Foreign Countries

The United States shares a tradition with France and the United Kingdom of educating large numbers of foreign students. In recent years, universities in other countries, notably Canada, Germany, and Japan, have also increased their number of foreign students.

Many of the United Kingdom's foreign students come from Britain's former colonies in Asia and North America (particularly India, Ireland, Malaysia, Singapore, Hong

Figure 2-36
S&E doctoral degrees in Europe, Asia, and North America, by field: 2000 or most recent year



NOTES: Natural sciences include physical, biological, earth, atmospheric, and ocean sciences. Asia includes China, India, Japan, South Korea, and Taiwan. Europe includes Western, Central, and Eastern Europe. See appendix table 2-36 for countries/economies included within each region.

SOURCES: Organization for Economic Co-operation and Development, *Education at a Glance 2002;* United Nations Educational, Scientific, and Cultural Organization (UNESCO), UNESCO Institute for Statistics database; and national sources. See appendix table 2-36.

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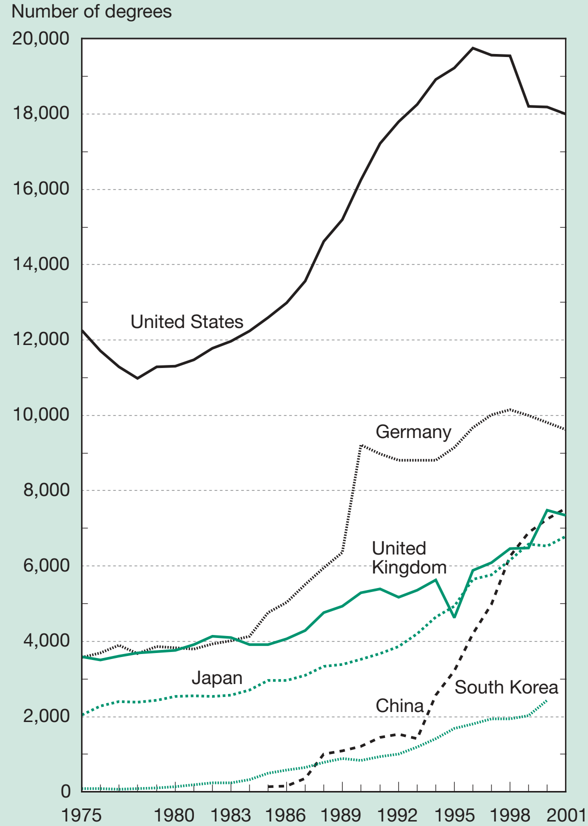
Figure 2-37
NS&E doctoral degrees, by selected countries: 1975–2001



NS&E natural sciences and engineering

NOTE: NS&E includes natural (physical, biological, earth, atmospheric, and ocean sciences), agricultural, and computer sciences; mathematics; and engineering.

SOURCES: China—National Research Center for Science and Technology for Development, special tabulations; United States—National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates; Japan—Government of Japan, Monbusho Survey of Education; South Korea—Ministry of Education, *Statistical Yearbook of Education,* and Organisation for Economic Co-operation and Development, *Education at a Glance 2002;* United Kingdom—Higher Education Statistics Agency; and Germany—Federal Statistical Office, *Prüfungen an Hochschulen*. See appendix tables 2-38 and 2-39.

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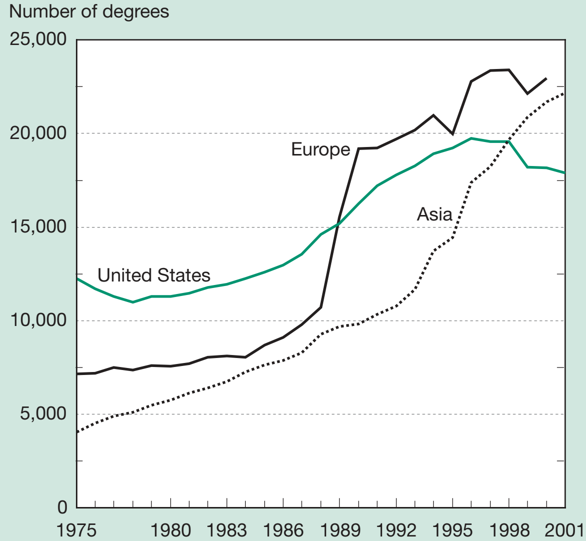
Figure 2-38
NS&E doctoral degrees in United States, Europe, and Asia: 1975–2001



NS&E natural sciences and engineering

NOTES: NS&E includes natural (physical, biological, earth, atmospheric, and ocean sciences), agricultural, and computer sciences; mathematics; and engineering. Europe includes only France, Germany, and the United Kingdom. Asia includes only China, India, Japan, South Korea, and Taiwan. The jump in the European data in 1989 is due to the inclusion of French data, which were unavailable in this data series before 1989. French data are estimated for 2000.

SOURCES: France—National Ministry of Education and Research, *Rapport sur les Études Doctorales;* Germany— Federal Statistical Office, *Prüfungen an Hochschulen;* United Kingdom—Higher Education Statistics Agency, special tabulations; China—National Research Center for Science and Technology for Development; India—Department of Science and Technology, *Research and Development Statistics;* Japan—Government of Japan, Monbusho Survey of Education; South Korea—Ministry of Education, *Statistical Yearbook of Education;* and Organisation for Economic Co-operation and Development, *Education at a Glance 2002;* Taiwan—Ministry of Education, *Educational Statistics of the Republic of China;* and United States—National Science Foundation, Division of Science Resources Statistics, *Science and Engineering Doctorate Awards*. See appendix tables 2-26, 2-38, and 2-39.

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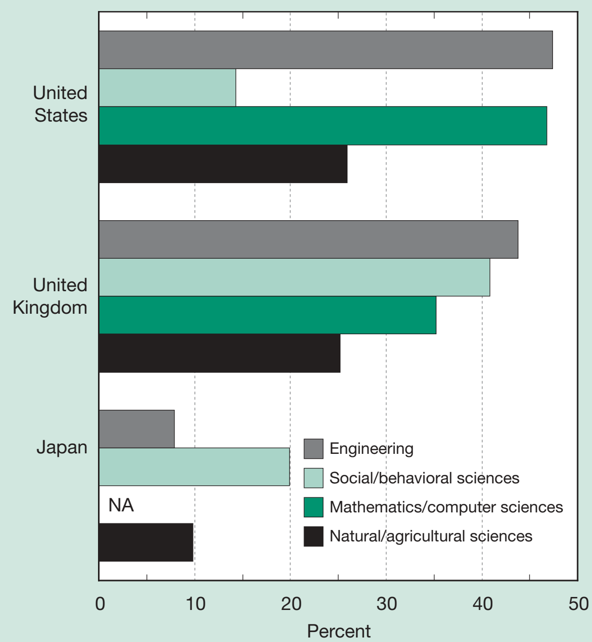
Kong, the United States, and Canada). In the 1990s, it began receiving more students from countries inside the European Union (EU). For example, in 1994, within the 10 top countries of origin, the number of foreign students from EU countries and former colonies were roughly equal. By 1998, in both graduate and undergraduate S&E programs, EU students were far more numerous in U.K. universities than students from former colonies. The number of students from China and Taiwan was also increasing (appendix table 2-40).

With an inflow of students from a broadening number of countries in the 1990s, the proportion of foreign students studying S&E in the United Kingdom increased at both the graduate and undergraduate level. Foreign undergraduate students in S&E increased from about 9 percent to almost 12 percent from 1995 to 1999, leveled off, and then declined in 2001. In undergraduate engineering, foreign student enrollment rose from 16,000 in 1995 to 21,000 in 1999 (the peak year for foreign undergraduate students), even as overall engineering enrollment declined from 113,000 to 100,000 (appendix table 2-40). At the graduate level, foreign S&E student enrollment increased continuously, from almost 29,000 in 1995 to 44,000 in 2001. By 2001, foreign students in the United Kingdom represented 44 percent of enrollment in graduate engineering programs and 35 percent in mathematics and computer sciences (figure 2-39).

Like the United Kingdom, France has a long tradition of educating students from its former colonies, as well as from developing countries in Africa and Latin America. In 1999, 7 of the 10 top countries of origin of foreign doctoral degree students in France were African (primarily Algeria, Morocco, and Tunisia) and Latin American (Brazil and Mexico) (National Science Board 2002). Also like the United Kingdom, the proportion of foreign students studying S&E fields in France increased at both the graduate and undergraduate level. Foreign undergraduate S&E enrollment in France increased from 7 percent in 1996 to 13 percent in 2002. In

Figure 2-39
Foreign S&E graduate student enrollment in selected countries, by field: 2001



NA not available

NOTES: Japanese data include mathematics in natural sciences and computer sciences in engineering. Natural sciences include physical, biological, earth, atmospheric, and ocean sciences. Foreign graduate enrollment in U.S. data includes temporary residents only; U.K. and Japanese data include permanent and temporary residents.

SOURCES: United States—National Science Foundation, Division of Science Resources Statistics, WebCASPAR database system, http://caspar.nsf.gov; United Kingdom—Higher Education Statistics Agency, special tabulations; and Japan—Government of Japan, Ministry of Education, Culture and Science, Division of Higher Education, special tabulations, 2003. See appendix tables 2-12, 2-40, and 2-42.

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the same period, foreign graduate S&E enrollment increased from 20 to 25 percent. Foreign graduate enrollment was higher in engineering fields, reaching 33 percent in 2002 (appendix table 2-41).

Japan, Canada, and Germany are also attempting to bolster enrollment of foreign students in S&E fields. Japan's goal of 100,000 foreign students, first promulgated in the early 1980s, is gradually being achieved. In 2001, almost 70,000 foreign students, mainly (more than 95 percent) from the Asian region enrolled in Japanese universities, and preliminary data for 2002 suggest that foreign enrollment has reached 100,000. In 2001, foreign student enrollment was concentrated at the undergraduate level (44,500) and in social and behavioral sciences (46 percent of undergraduates enrolled).[20] Japan also enrolled about 25,000 foreign students at the graduate level, mainly from China and South Korea, and foreign students represented 12 percent of the graduate students in S&E fields (appendix table 2-42).

Like the United Kingdom, Canada has traditionally educated foreign students from British Commonwealth countries. In 1985, these countries were 6 of the 10 top countries of origin of foreign S&E students in Canada. As foreign student flows increased in the 1990s, the top countries of origin of foreign students in Canada shifted toward non-Commonwealth countries in Asia, Europe, and the Middle East (appendix table 2-43).[21]

From 1985 to 1998, Canada enrolled an increasing number of foreign students in its graduate and undergraduate S&E programs. By 1998, 16,700 foreign graduate S&E students were enrolled in Canadian universities, up from 9,400 in 1985. In 1998, foreign students represented about 9 percent of undergraduate enrollment in S&E fields, with larger percentages in mathematics and physical sciences (16 percent) and engineering and applied sciences (13 percent). These percentages were up slightly from 1985 (appendix table 2-43). Foreign students represented 21 percent of all graduate S&E students in Canada in 1998, compared with 17 percent in 1985, with higher foreign representation in mathematics and physical sciences (30 percent) and engineering and applied sciences (32 percent).

Germany is recruiting students from India and China to fill its research universities, particularly in engineering and computer sciences (Grote 2000 and Koenig 2001). Germany has also established bachelor's and master's degree programs taught in English to attract students from the United States, Europe, and other countries. Since 2000, Germany's report of higher education statistics has included earned bachelor's and master's degrees in these new types of programs.

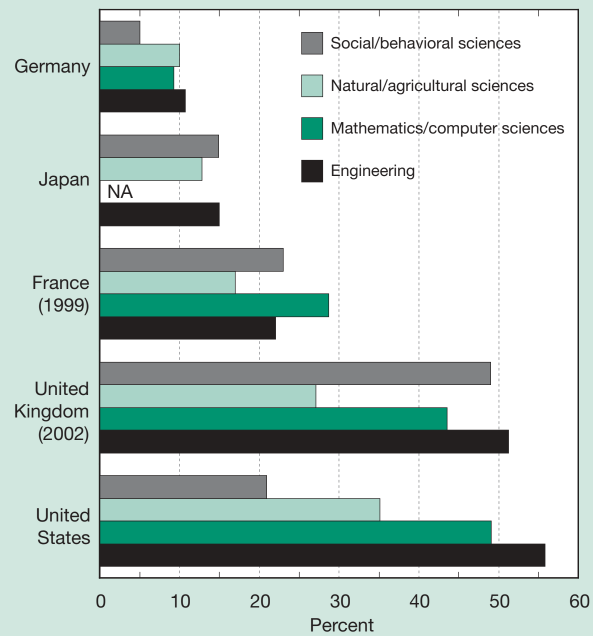
International Comparison of Foreign Doctoral Degree Recipients

Like the United States, the United Kingdom and France have many foreign students among their S&E doctoral degree recipients. By 2001, around 36 percent of S&E doctorates from U.K. and U.S. universities were awarded to foreign students. Almost 21 percent of French S&E doctoral recipients were foreign (appendix table 2-44).

The percentage of foreign doctoral degree recipients was generally higher in engineering, mathematics, and computer sciences. Foreign students earned 56 percent of the engineering degrees awarded by U.S. universities, 51 percent of those awarded by U.K. universities, and 22 percent of those awarded by French universities. Foreign students earned 49 percent of the mathematics and computer science doctorates awarded by U.S. universities, 44 percent of those awarded by U.K. universities, and 29 percent of those awarded by French universities. In addition, Japan and Germany had a modest but growing percentage of foreign students among their S&E doctoral degree recipients (figure 2-40 and appendix table 2-44).

The internationalization of S&E higher education can benefit both industrialized and developing countries. (See sidebar, "Contributions of Developed Countries to Increasing Global S&E Capacity.")

Figure 2-40
S&E doctoral degrees earned by foreign students in selected countries, by field: 2001 or most recent year



NA not available

NOTES: Japanese data are for university-based doctorates only; excludes *ronbun hakase* doctorates awarded for research within industry. Japanese data include mathematics in natural sciences and computer sciences in engineering. For each country, data are for doctoral degree recipients with foreign citizenship, including permanent and temporary residents. Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

SOURCES: France—National Ministry of Education and Research, *Rapport sur les Études Doctorales 2001;* Germany— Federal Statistical Office, *Prüfungen an Hochschulen 2001;* Japan—Government of Japan, Ministry of Education, Culture and Science, Division of Higher Education, special tabulations; United Kingdom—Higher Education Statistics Agency, special tabulations, 2003; and United States—National Science Foundation, Division of Science Resources Statistics, *Science and Engineering Doctorate Awards: 2001*. See appendix table 2-44.

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[20]At the undergraduate level, about 20 percent of foreign students are permanent residents in Japan. In contrast, at the graduate level, only 5 percent of foreign students are permanent residents.

[21]Unpublished tabulations provided by Statistics Canada, 2002.

Contributions of Developed Countries to Increasing Global S&E Capacity

The doctoral faculty in many developing and emerging countries have been trained in Western industrialized countries.* From 1985 to 2001, U.S. universities trained 148,000 foreign doctoral students in S&E fields (appendix table 2-28). Most (89 percent) of these foreign doctoral degree recipients were from developing countries/economies throughout the world, particularly Asia.† In addition, the United Kingdom, France, and Canada contributed significantly to educating many S&E students from developing countries, at both the graduate and undergraduate level. As student mobility increases, particularly for graduate S&E education, host countries receive students from a broader spectrum of developing countries (appendix tables 2-40, 2-42, and 2-43).

Foreign S&E doctoral degree recipients who returned home after study abroad have contributed to the expansion of S&E graduate programs and the improvement of faculty credentials and research capacity in several developing countries. U.S. S&E doctoral degree recipients from China who returned home in the 1980s expanded higher education and graduate S&E programs. China's successful participation in the Human Genome Project in the 1990s was facilitated by recruiting Chinese scientists and engineers educated abroad to 20 institutes in Beijing and Shanghai (Li 2000). The return flow of South Korean and Taiwanese S&E doctoral degree recipients from U.S. universities in the 1980s and 1990s was often to faculty positions within their home country (Song 1997).

Foreign doctoral degree recipients who remain abroad become part of an increasingly international S&E higher education system and often participate in international collaborative research. By the end of the 20th century, about 35 percent of the computer science and engineering faculties at U.S. universities and colleges were foreign born, as were nearly 30 percent of mathematics faculty and about 20 percent of the faculties in physical, life, and social sciences (National Science Board 2002). International collaborations that include U.S. S&E faculty contribute to research programs that strengthen the scientific capacity of developing countries.‡ For example, Biocomplexity in the Environment encourages international biodiversity research on therapeutic plants in the context of conservation and sustainable economic development and includes funds for equipment and human resource development in developing countries. U.S. universities are attempting to create an Internet-based worldwide materials research network to enhance scientific and educational collaborations. Materials Research Science and Engineering Centers within U.S. universities have active international collaborations between U.S. researchers and educators and their counterparts in Africa, the Americas, Asia, Europe, and the Pacific region.§

*College catalogs in developing countries generally list faculty with the name of the university and department in which they earned their doctorate.

†National Science Foundation, Division of Science Resources Statistics, Survey of Earned Doctorates, special tabulations, 2003.

‡U.S. institutions and S&E faculty are active in international distance education in developing countries, advise on establishing centers of excellence, accept students from abroad, and establish international collaborative research with their former students. For more information, see Arnone (2001) and Takle (1999).

§For more information, see *International Dimensions of NSF Research & Education,* http://www.nsf.gov/sbe/int/pubs/02overview/start.htm.

Conclusion

Governments around the world are expanding access to higher education to develop an educated workforce that will contribute to economic growth and competitiveness. Many countries have successfully increased the rate at which their college-age citizens earn S&E degrees. The United States has been less successful in this regard, particularly in the combined natural sciences, mathematics, computer sciences, and engineering fields that are considered critical to technological innovation. At the same time, mature industrial countries facing adverse demographic shifts are considering strategies to import highly trained foreign labor, especially from developing nations.

In the United States, freshmen continue to show considerable interest in S&E fields and appear to be no less prepared to undertake such study than they were 1 or 2 decades ago. However, sizable numbers indicate a need for remedial instruction in mathematics and the sciences, perhaps indicating weak spots in students' secondary education. In any case, as the number of U.S. bachelor's degrees has expanded, the share going to S&E degrees has held steady. However, shifts among S&E fields have been toward biological, social, and behavioral sciences and away from physical sciences and engineering.

Demographic trends that will shape U.S. higher education can already be seen. Women now represent the majority of students; they also earn most of the bachelor's degrees and half of the bachelor's degrees in S&E. Minority students from all groups are earning greater degree shares, with faster progress at the lower degree levels than at the doctorate level. As the share of underrepresented minorities in the college-age population grows, it is critical to entice them into S&E fields, where their attainment gap with whites remains large.

At advanced education levels, these trends come into sharper focus. Declining numbers of white men complete advanced S&E training; some of the women's numbers are also becoming flat or declining. Growing populations of minority groups counterbalance some of this trend, but growth in advanced S&E degrees primarily reflects strongly rising numbers of foreign students.

Through 2001, the last year of available data, the U.S. retained and even increased its attractiveness to these foreign students. The rate at which doctoral students remained here after receipt of their doctorate rose well above longer-term averages during the late 1990s. In the period 1998–2001, 76 percent reported plans to stay, and 54 percent had firm commitments to do so.

Nonetheless, the worldwide economic downturns and the events of September 11, 2001, introduce uncertainties into this picture. The latter especially has long-term ramifications, and even the initial impact is not yet captured in these data. Some evidence suggests that lower numbers of student and exchange visas are being granted. At this writing, it is unclear to what extent this evidence represents fewer applications, slower or more critical processing, a change in relative economic conditions, or a combination of these and other factors.

These developments occur in the context of continuing extension of global markets; worldwide reach of networks of scientific and technical activity, cooperation, and competition; and global flows of highly trained personnel. As government efforts to develop centers of excellence bear fruit, and as industry locates in developing markets and regions with newly developed technological competency, continuing shifts will take place in the international distribution of jobs and employment requiring high skill levels and technically sophisticated training. The shifts will, in turn, elicit responses from worldwide higher education systems.

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