Chapter 3
Science and Engineering Labor Force

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Highlights

- **Since 1980, the number of nonacademic science and engineering jobs has grown at more than four times the rate of the U.S. labor force as a whole.** Nonacademic S&E jobs increased by 159 percent between 1980 and 2000, an average annual growth rate of 4.9 percent (compared with 1.1 percent for the entire labor force).
- **Even among S&E bachelor's degree holders working in non-S&E occupations, more than two-thirds reported that their job related to their field of degree.** Because individuals use S&E knowledge in a wide variety of areas, a purely occupation-based definition of the S&E labor force is too limiting.
- **Barring changes in degree production or in immigration, the S&E labor force will grow at a slower rate and the average age of scientists and engineers will increase.** The age distribution of individuals with S&E degrees implies this change.
- **The total number of retirements among S&E-degreed workers will increase dramatically over the next 20 years, barring large changes in retirement rates.** More than half of S&E-degreed workers are age 40 or older, and the 40–44 age group is nearly four times as large as the 60–64 age group.
- **Labor market conditions for individuals with S&E degrees improved during the 1990s; however, unemployment in S&E occupations reached a 20-year high in 2002.** Holders of S&E bachelor's degrees had lower unemployment rates and were significantly more likely to work in jobs related to their degree in 1999 compared with 1993. However, by 2002, overall unemployment rates for individuals in S&E occupations (regardless of education) had risen to 3.9 percent.
- **The share of foreign-born scientists and engineers in the U.S. S&E workforce rose to a record in 2000, reflecting high levels of entry by both permanent and temporary visa holders during the 1990s.** Data from the 2000 U.S. Census show that, in S&E occupations, approximately 17 percent of bachelor's degree holders, 29 percent of master's degree holders, and 38 percent of doctorate holders are foreign born.
- **A decline in student, exchange, and temporary high-skilled worker visas issued since 2001 interrupted a long-term trend of growth.** The number of student visas and of temporary high-skilled worker visas issued both declined by more than one-fourth since FY 2001. These declines were due both to fewer applications and to an increase in the proportion of visa applications rejected.
- **There is increased recruitment of high-skilled labor, including scientists and engineers, by many national governments and private firms.** For example, in 1999, 241,000 individuals entered Japan with temporary high-skill work visas, a 75 percent increase over 1992.

Introduction

Chapter Overview

Although workers with science and engineering skills make up only a small fraction of the total U.S. civilian labor force, their impact on society belies their numbers. These workers contribute enormously to technological innovation and economic growth, research, and increased knowledge. Workers with S&E skills include technicians and technologists, researchers, educators, and managers. In addition, there are many others with S&E training who use their skills in a variety of nominally non-S&E occupations (such as writers, financial managers, paralegals) and many niches in the labor market where the need to interpret and use S&E knowledge is key.

Chapter Organization

This chapter has four major sections. First is a general profile of the S&E labor force. This includes the demographic characteristics (population size, gender, and race/ethnicity) of the S&E labor force. It also covers educational backgrounds, earnings, places of employment, occupations, and whether the S&E labor force makes use of S&E training. Much of the data in this section in available only through 1999 due to the temporary discontinuation of the National Survey of College Graduates (NSCG) of the National Science Foundation (NSF), which is the central part of NSF's Scientists and Engineers Statistical Data System (SESTAT) data system on scientists and engineers.[1]

Second is a look at the labor market conditions for recent S&E graduates—graduates whose labor market outcomes are most sensitive to labor market conditions. For recent S&E doctoral degree recipients, the special topics of academic employment and postdoctoral appointments (hereafter referred to by the colloquial term *postdocs*) are also examined.

Third is the age and retirement profile of the S&E labor force. This is key to gaining insights into the possible future structure and size of the S&E educated population.

The last section focuses on the global S&E labor force—both its growth abroad and the importance of the international migration of scientists and engineers to the United States and the world.

U.S. S&E Labor Force Profile

This section profiles the U.S. S&E labor force, providing specific information about its size, recent growth patterns, projected labor demand, and trends in sector of employment. It also looks at workers' use of their S&E training, educational background, and salaries.[2]

Section Overview

The S&E labor force includes both individuals in S&E occupations and many others with S&E training who may use their knowledge in a variety of different jobs. Employment in S&E occupations has grown rapidly over the past 2 decades and is currently projected to continue to grow faster than general employment through the next decade. Although most individuals with S&E degrees do not work in occupations with formal S&E titles, most of them, even at the bachelor's degree level, report doing work related to their degree even in mid- and late-career. Compared with the general labor force, S&E occupations generally have lower unemployment rates. However, the economic downturn that began in 2001 has caused S&E unemployment rates to rise faster than the national average, narrowing that gap. The proportion of women and ethnic minorities in the S&E labor force continues to grow but, with the exception of Asian/Pacific Islanders, remains smaller than their proportion of the overall population.

How Large Is the U.S. S&E Workforce?

Estimates of the size of the U.S. S&E workforce vary based on the criteria used to define *scientist* or *engineer*. Education, occupation, field of degree, and field of employment are all factors that may be considered.[3] (See sidebar, "Who Is a Scientist or an Engineer?" and appendix table 3-1.)

The size of the S&E workforce in 1999 (the most recent year for which both occupational and education information are available) varies between approximately 3 million and 10 million individuals, depending on the definition and perspective used. Although the Bureau of Labor Statistics' (BLS) Current Population Survey (CPS) counted 5.3

[1]Budgetary considerations precluded conducting the 2001 National Survey of College Graduates (NSCG), which provides population estimates for approximately 85 percent of the science and engineering labor force within the Scientists and Engineers Statistical Data System (SESTAT). The NSCG is being restarted with a new sample in 2003.

[2]Much of the data in this section comes from SESTAT, a unified database that contains information on the employment, education, and demographic characteristics of scientists and engineers in the United States. The National Science Foundation, Division of Science Resources Statistics (NSF/SRS) derives SESTAT data from three of its surveys: the National Survey of College Graduates, the NSCG, and the Survey of Doctorate Recipients. Because the NSCG did not take place in 2001, SESTAT data is current only through 1999. (These surveys generally take place every 2 years.) NSF/SRS surveys U.S. residents who hold at least a bachelor's degree (in either an S&E or non-S&E field) and who, during the survey's reference period, were not institutionalized, were age 75 or younger, and either had trained or were working as a scientist or engineer. (That is, participants either had at least one bachelor's degree or higher in an S&E field, or had a bachelor's degree or higher in a non-S&E field and worked in an S&E occupation.) The 1999 SESTAT surveys used the week beginning April 15, 1999, as their reference period.

[3]For a detailed discussion of the S&E degree fields and occupations in SESTAT, see NSF/SRS 1999a. A list of S&E occupations and fields is contained in appendix table 3-1. In general, S&E occupations and fields in this report include individuals working in social sciences and exclude medical practitioners and technicians (including computer programmers). Thus, a physician with an M.D. will not be considered to be a scientist or engineer either by occupation or by highest degree, but is likely (but not certain) to be included in statistics that incorporate individuals with S&E degrees based on their field of bachelor's degree.

Who Is a Scientist or an Engineer?

The terms *scientist* and *engineer* have many definitions, none of them perfect. (For a more thorough discussion, see *SESTAT and NIOEM: Two Federal Databases Provide Complementary Information on the Science and Technology Labor Force* (NSF/SRS 1999b) and "Counting the S&E Workforce—It's Not That Easy" (NSF/SRS 1999a). This chapter uses multiple definitions for different analytic purposes; other reports use even more definitions. The three main definitions used in this chapter follow:

- **Occupation.** The most common way to count scientists and engineers in the workforce is to include individuals having an occupational classification that matches some list of science and engineering occupations. Although considerable questions can arise regarding how well individual write-ins or employer classifications are coded, the occupation classification comes closest to defining the work a person performs. (For example, an engineer by occupation may or may not have an engineering degree.) One limitation of classifying by occupation is that it will not capture individuals using S&E knowledge, sometimes extensively, under occupational titles such as manager, salesman, or writer.[*] It is common for persons with an S&E degree in such occupations to report that their work is closely related to their degree and, in many cases, to also report research and development as a major work activity.
- **Highest degree.** Another way to classify scientists and engineers is to focus on the field of their highest (or most recent) degree. For example, classifying as "chemist" a person who has a bachelor's degree in chemistry—but who works as a technical writer for a professional chemists' society magazine—may be appropriate. Using this "highest degree earned" classification does not solve all problems, however. For example, should a person with a bachelor's degree in biology and a master's degree in engineering be included among biologists or engineers? Should a person with a bachelor's degree in political science be counted among social scientists if he also has a law degree? Classifying by highest degree earned in situations similar to the above examples may be appropriate, but one may be uncomfortable excluding an individual who has both a bachelor's degree in engineering and a master's degree in business administration from an S&E workforce analysis.
- **Anyone with an S&E degree or occupation.** Classification by both occupation and education is another approach. NSF's sample surveys of scientists and engineers attempt to include U.S. residents who either have an S&E degree or an S&E occupation.[†]

[*]For example, in most collections of occupation data a generic classification of postsecondary teacher fails to properly classify many university professors who would otherwise be included by most definitions of the S&E workforce. The Scientists and Engineers Statistical Data System (SESTAT) data mostly avoids this problem through use of a different survey question, coding rules, and respondent followups.

[†]Individuals who lacked U.S. S&E degrees but who earned S&E degrees in another country are included in 1999 SESTAT data to the extent that they were in the United States in 1990, as were individuals who had at least bachelor's degrees in some non-S&E field and who were working in S&E occupations in 1993.

million individuals in S&E occupations, a separate NSF survey found 3.3 million holders of S&E degrees in S&E occupations (table 3-1 and BLS 2001). This difference may reflect the inclusion of both individuals employed in S&E occupations who did not earn at least a bachelor's degree and individuals with non-S&E degrees; it may also partially stem from other technical differences between the surveys.

In 1999, 10.5 million employed individuals had at least one degree in an S&E field. This broader definition of the S&E workforce relates to many of the ways science and technical knowledge is used in the United States.

Table 3-1
Measures of S&E workforce: 1999

Measure and degree status	Workforce
BLS Current Population Survey	
All employed in S&E	5,294,000
With bachelor's degree or higher	4,021,000
SESTAT data system	
Employed S&E degree holders	10,480,000
In S&E occupation	3,259,000

BLS Bureau of Labor Statistics

SOURCES: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999; and National Bureau of Economic Research's Merged Outgoing Rotation Group Files from the Bureau of Labor Statistics' Current Population Survey.

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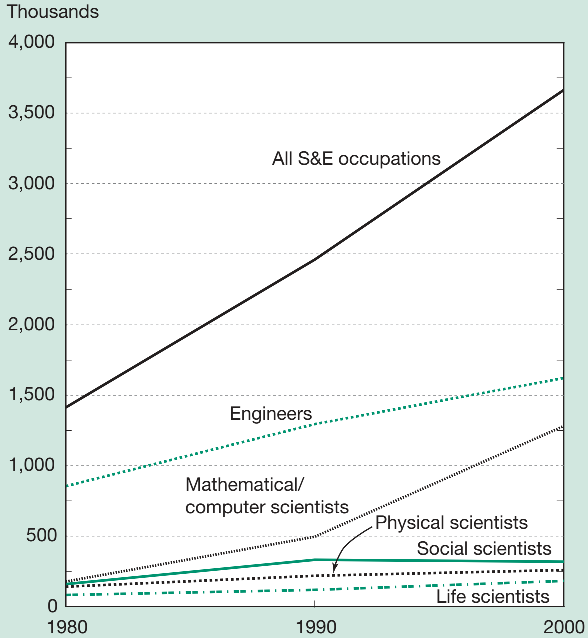
S&E Workforce Growth

Despite some limitations in measuring the S&E labor force, occupation classifications allow examination of growth in at least one measure of scientists and engineers over extended periods. Using data from the decennial census, the number of college graduates working in narrowly defined S&E occupations (excluding technicians and computer programmers) and employed outside academia increased by 159 percent between 1980 and 2000, to a total of 3.6 million jobs in 2000 (figure 3-1).[4] This represents a 4.9

[4]Another difficulty when using occupation to identify scientists and engineers in many data sources other than SESTAT is that many workers in academia are identified by occupational titles that do not indicate academic specialty. For that reason, the time trend examined here is only for individuals outside academic employment.

Figure 3-1
College graduates in nonacademic S&E occupations, by occupation: 1980, 1990, and 2000



SOURCES: U.S. Decennial Census Public Use Microdata Samples, 1980 and 1990; and National Bureau of Economic Research's Merged Outgoing Rotation Group files from the Bureau of Labor Statistics' Current Population Survey. See appendix table 3-2.

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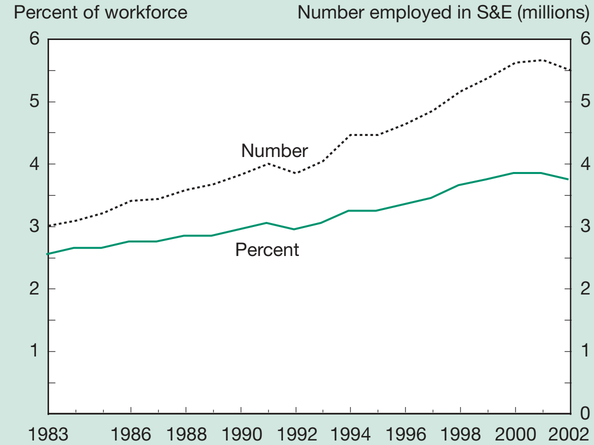
Figure 3-2
U.S. workforce in S&E occupations: 1983–2002



SOURCES: U.S. Decennial Census Public Use Microdata Samples, 1980 and 1990; and National Bureau of Economic Research's Merged Outgoing Rotation Group files from the Bureau of Labor Statistics' Current Population Survey. See appendix table 3-3.

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percent average annual growth rate, much more than the 1.1 percent average annual growth rate of the entire labor force.

Although every broad S&E occupational group grew between 1980 and 2000 (the lowest growth, 81 percent, occurred in physical sciences), the most explosive growth was in mathematics and computer sciences, which experienced a 623 percent increase (177,000 jobs in 1980 compared with 1.28 million jobs in 2000).

Using data from the monthly CPS from 1993 to 2002 to look at employment in S&E occupations across all sectors and education levels creates a very similar view, albeit with some significant differences. The 3.1 average annual growth rate in all S&E employment is almost triple the rate for the general workforce. This is reflected in the growing proportion of total jobs in S&E occupations, which increased from 2.6 percent in 1983 to 3.8 percent in 2002. Also noteworthy are the decreases in employment in S&E occupations between 1991 and 1992 and between 2001 and 2002—evidence that S&E employment is not exempt from economic downturns (figure 3-2).

Projected Demand for S&E Workers

The most recent occupational projections from the BLS, for the period from 2000–10, predict that employment in S&E occupations will increase about three times faster than the overall growth rate for all occupations (table 3-2). (Although BLS made these projections before the most recent economic downturn, they may still be indicative of long-term trends.) The economy as a whole is expected to provide approximately 15 percent more jobs over this decade, with employment opportunities for S&E jobs expected to increase by 2.2 million jobs, or about 47 percent (BLS 2001).

Approximately 86 percent of the projected increase in S&E jobs is in computer-related occupations. Indeed, without computer and mathematical occupations, the projected growth in S&E occupational employment would be just slightly more than overall employment growth (figure 3-3). The number of jobs for computer software engineers is expected to increase from 697,000 to 1.4 million and employment for computer systems analysts is expected to grow from 431,000 to 689,000 jobs.

Within engineering occupations, environmental engineering is projected to have the biggest relative employment gains, increasing by 14,000 jobs or about 27 percent. Computer hardware engineering is also expected to experience above-average employment gains, growing by 25 percent. Employment for all engineering occupations is expected to increase by less than 10 percent.

Projected job opportunities in life science occupations will grow by almost 18 percent (33,000 new jobs) from 2000 to 2010. At 27 percent (10,000 new jobs), medical science occupations will experience the largest predicted growth. BLS expects employment in physical science occupations to increase by about 18 percent (from 239,000 to 283,000 jobs), with slightly less than half of these projected job gains for environmental scientists (21,000 new jobs).

Finally, predictions indicate that social science occupations will experience above-average growth of 20 percent, largely due to the employment increases anticipated for market and survey researchers (27 percent or 30,000 new jobs).

Table 3-2
Total S&E jobs: 2000 and projected 2010
(Thousands)

Occupation	2000	2010	Change
All occupations	145,571	167,754	22,183
All S&E occupations	4,706	6,904	2,197
Scientists	3,241	5,301	2,059
Life scientists	184	218	33
Mathematical/computer scientists	2,408	4,308	1,900
Computer specialists	2,318	4,213	1,895
Mathematical scientists	89	95	5
Physical scientists	239	283	44
Social scientists	410	492	82
Engineers	1,465	1,603	138

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections. See appendix table 3-4.

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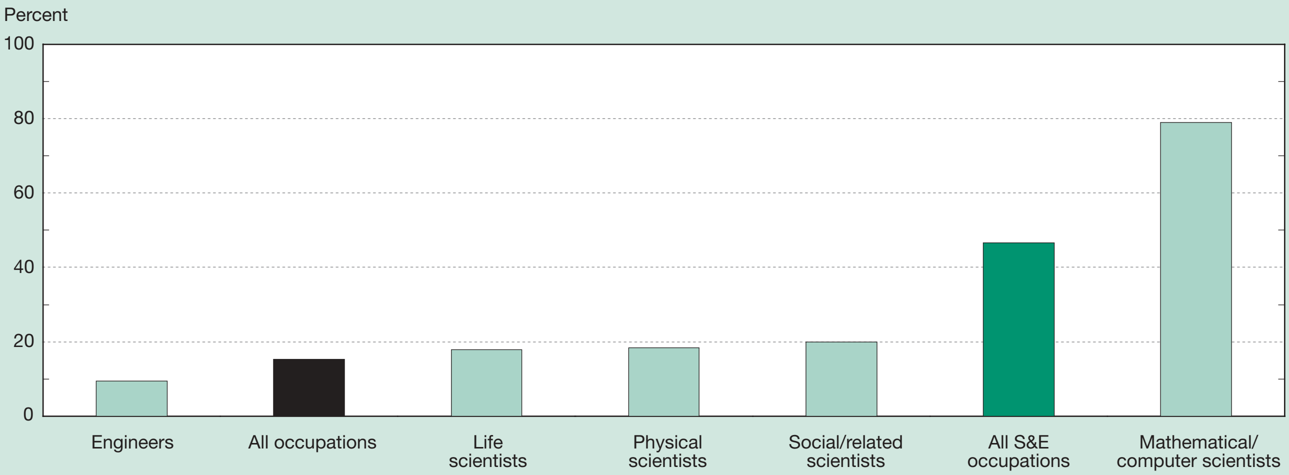
Figure 3-3
Projected increase in employment, by occupation: 2000–10



SOURCE: U.S. Department of Labor, Bureau of Labor Statistics, Office of Occupational Statistics and Employment Projections. See appendix table 3-4.

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How Are People With an S&E Education Employed?

Although the majority of S&E degree holders do not work in S&E occupations, this does not mean they do not use their S&E training. In 1999, of the 5 million individuals whose highest degree was in a S&E field and who did not work in S&E occupations, 67 percent indicated that they worked in a job at least somewhat related to the field of their highest S&E degree (table 3-3).[5] According to 1999 SESTAT data, almost 80 percent of individuals whose highest degree earned was in mathematics or computer sciences and who worked in non-S&E jobs reported working in fields related to their degree, compared with 63 percent of individuals whose highest degree earned was in social or physical sciences.

Of all employed individuals whose highest degree was in S&E, 77 percent reported their jobs as at least somewhat related to the fields of their highest degree and 46 percent reported their jobs as closely related to their field (appendix tables 3-5 and 3-6).[6] In the 1–4-year period after receiving their degrees, 73 percent of S&E doctorate holders say that they have jobs closely related to the degrees they received compared with 68 percent of master's degree recipients and 42 percent of bachelor's degree recipients (figure 3-4). This relative ordering of relatedness by level of degree holds

[5]Because this question asked only about the field of an individual's highest degree, it is not possible to evaluate the science and engineering content of jobs held by S&E degree holders with non-S&E advanced degrees, such as MBAs and M.D.s.

[6]Although self-assessments by survey respondents are highly subjective, they may capture associations between training and scientific expertise not evident through occupational classifications. For example, an individual with an engineering degree, but with an occupational title of salesman, may still use or develop technology.

Table 3-3
S&E degree holders employed in non-S&E occupations, by highest degree and relation of degree to job: 1999

Highest degree	Degree holders	Degree related to job: Closely	Somewhat	Not
	Number	Percent		
All degrees[a]	4,976,900	33.2	34.1	32.7
Bachelor's	4,092,800	29.9	34.7	35.5
Master's	724,800	48.7	31.2	20.1
Doctoral	155,200	46.0	35.6	18.5

[a]Includes professional degrees.

NOTE: Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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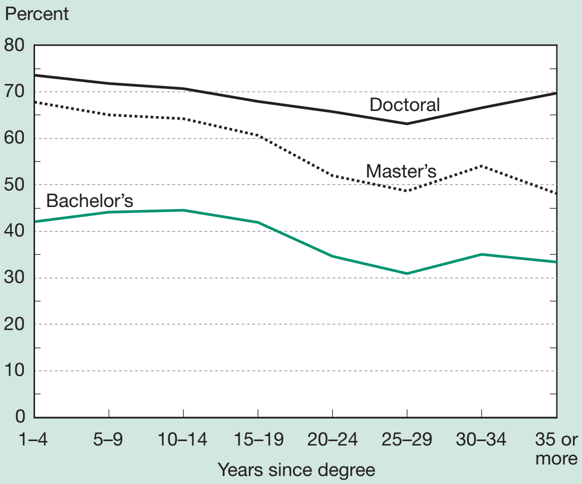
Figure 3-4
S&E degree holders employed in jobs closely related to highest degree, by highest degree and years since degree: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT),1999. See appendix table 3-6.

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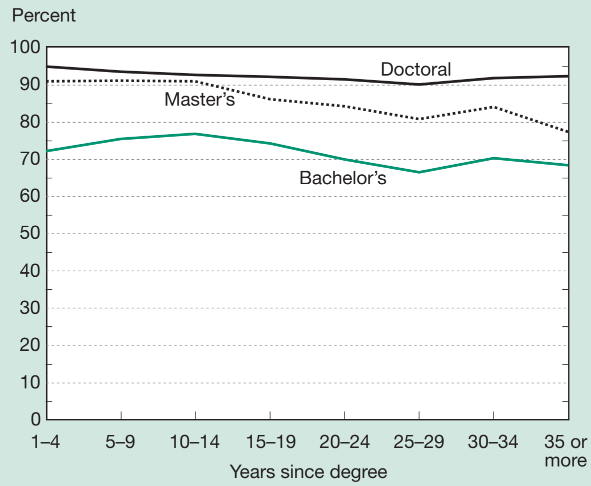
across all periods of years since recipients received their degrees. However, at every degree level, the relatedness of job to degrees falls with time since degree.[7] There are many good reasons for this trend: individuals may change their career interests over time, gain skills in different areas while working, take on general management responsibilities, and forget some of their original college training (or some of their original college training may become obsolete). Given these possibilities, the career-cycle decline in the relevance of an S&E degree is only modest. When a somewhat weaker criterion is used—are jobs "closely" or "somewhat" related to an individual's field of highest degree—even higher proportions of S&E graduates report their jobs being related to their degrees. Over 70 percent of S&E bachelor's degree holders report their jobs at least somewhat related to their field of degree until 25–29 years after their degrees. Among S&E doctorate holders at any point in their careers, less than 10 percent report their jobs as not related to their field of degree (figure 3-5).

Figure 3-6 shows differences in the percentages of individuals who reported their job as closely related to their field of degree, by major S&E disciplines for bachelor's degree holders. Although mathematics and computer sciences often are combined into a single group, figure 3-6 shows them

Figure 3-5
S&E highest degree holders employed in jobs closely or somewhat related to highest degree, by years since degree: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT),1999. See appendix table 3-5.

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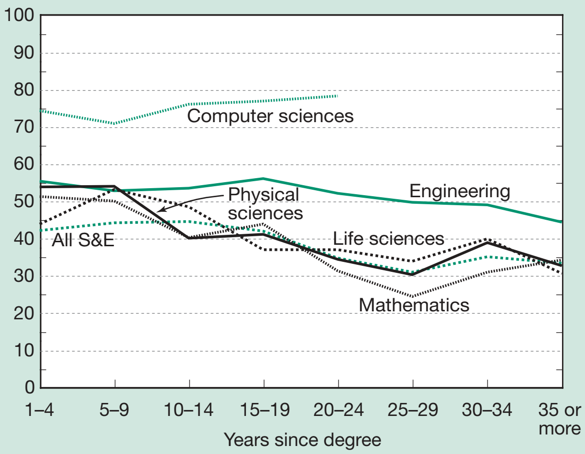
[7]The only exception is for doctorate holders who earned their degrees more than 25 years ago, where the percentage of individuals holding jobs closely related to their degrees actually increased. This may reflect differences in retirement rates.

Figure 3-6
S&E bachelor's degree holders employed in jobs closely related to degree, by field and years since degree: 1999



NOTE: Computer science degrees were not awarded in significant numbers more than 25 years ago.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-6.

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separately because of their differing patterns. From 1–4 years after receiving their degrees, the percentage of S&E bachelor's degree holders who reported their jobs as closely related to their field of degree ranged from 30 percent for individuals with degrees in social sciences to 74 percent for individuals with degrees in computer sciences. Between these extremes, most other S&E fields show similar percentages for recent graduates: 55 percent for engineering, 54 percent for physical sciences, 52 percent for mathematics, and 44 percent for life sciences.

Employment in Non-S&E Occupations

About 5 million S&E degree holders worked in non-S&E occupations in 1999. Slightly more than half held management or administrative positions (28 percent), sales and marketing jobs (15 percent), or K–12 teaching posts (9 percent). About 89 percent of non-S&E K–12 teachers reported their work as at least somewhat related to their S&E degree compared with approximately 73 percent of managers and administrators and 51 percent of individuals holding sales and marketing jobs (table 3-4).

About 83 percent of the 5 million S&E degree holders not working in S&E occupations in 1999 reported their highest degree as a bachelor's degree; 15 percent listed a master's degree; and 3 percent, a doctorate. Among individuals with a bachelor's degree, approximately two-thirds reported their jobs as closely or somewhat related to their field of highest degree compared with four-fifths of S&E doctoral degree recipients and master's degree recipients (table 3-3).

Employment in S&E Occupations

Because S&E knowledge is used so widely across so many different jobs, a count of individuals in S&E occupations is one of the narrowest definitions of the S&E labor force. Of the nearly 8 million individuals in the labor force in 1999 whose highest degree earned was in an S&E field, slightly more than one-third (3 million) worked in S&E occupations. In addition, 2.5 million people who had received training in S&E disciplines, but whose highest degree was in a non-S&E field, were employed in S&E occupations. Another 282,000 college-educated individuals were employed in S&E occupations but did not hold a degree in an S&E field (table 3-5).

Table 3-4
Individuals with S&E highest degree employed in non-S&E occupations, by occupation and relation of degree to job: 1999

Occupation	Degree holders	Degree related to job: Closely	Somewhat	Not
	Number	Percent		
All non-S&E occupations	4,976,900	33.2	34.1	32.7
Managers/administrators	1,416,000	30.0	43.0	27.0
Sales/marketing	764,400	13.3	37.5	49.2
K–12 teachers	452,400	65.8	22.7	11.5
Technologists/technicians	337,600	46.6	34.1	19.3
Health related	322,200	58.1	27.1	14.7
Social services	291,500	61.2	28.7	10.0
Arts/humanities	122,500	21.7	38.1	40.2
Non-S&E postsecondary teachers	50,000	68.1	23.7	8.2
Other	1,220,400	20.0	29.2	50.8

NOTE: Details may not add to totals because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Table 3-5
College-educated individuals with S&E degrees or S&E occupations, by S&E employment status and field of highest degree: 1999

Degree status	All occupations	S&E occupations	Non-S&E occupations
All college educated	10,761,800	3,540,800	7,221,000
No S&E degree in S&E occupation	282,000	282,000	na
S&E degree	10,479,800	3,258,800	7,221,000
S&E highest degree	7,980,000	3,003,200	4,976,800
Engineering	1,936,400	1,303,300	633,100
Life and related sciences	1,287,700	361,700	926,000
Mathematics/computer sciences	1,045,800	537,200	508,600
Physical and related sciences	621,700	343,000	278,700
Social and related sciences	3,088,400	458,000	2,630,400
Non-S&E highest degree	2,499,800	255,600	2,244,200

na not applicable

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Table 3-6
Individuals in S&E occupations, by highest degree: 1999
(Percent distribution)

Occupation	All degrees	Bachelor's	Master's	Doctoral	Professional
All S&E occupations	100.0	100.0	100.0	100.0	100.0
Engineers	38.7	45.5	36.5	17.4	7.2
Life and related scientists	9.7	6.8	7.0	25.0	42.2
Mathematical/computer scientists	33.0	37.1	34.3	13.9	18.8
Physical and related scientists	8.4	7.0	7.1	17.5	1.4
Social and related scientists	10.3	3.6	15.1	26.2	30.4

NOTE: Percents may not sum to 100 because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Altogether, approximately 3.5 million individuals with S&E degrees worked in S&E occupations in 1999 (appendix table 3-7). Engineers represented 39 percent (1.37 million), and computer scientists and mathematicians, 33 percent (1.17 million). Physical scientists accounted for less than 9 percent.

By subfield, electrical engineers made up about one-fourth (362,300) of all individuals employed as engineers, whereas biologists accounted for about three-fifths (206,500) of employment in life sciences. In physical and social science occupations, chemistry (121,700) and psychology (197,000), respectively, were the largest occupational subfields.

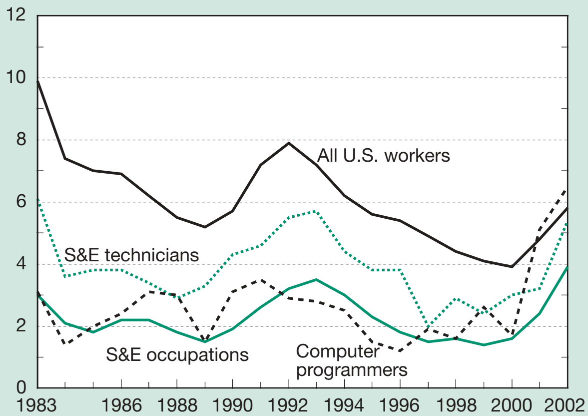
Approximately 56 percent of individuals employed in S&E occupations reported a bachelor's degree as their highest degree earned, whereas about 29 percent listed a master's degree and 14 percent, a doctorate. Almost half of bachelor's degree recipients were engineers; slightly more than one-third were computer scientists and mathematicians. These occupations were also the most prominent among individuals with master's degrees, at approximately 37 and 34 percent, respectively (table 3-6).

Unemployment

A two-decades long view of unemployment trends in S&E occupations, regardless of education level, comes from the CPS data for 1983–2002.[8] During this 20-year period, the unemployment rate for all individuals in S&E occupations ranged from a low of 1.4 percent in 1999 to a high of 3.9 percent in 2002. Overall, the S&E occupational unemployment rate was both lower and less volatile than either the rate for all U.S. workers (ranging from 3.9 to 9.9 percent) or for S&E technicians (ranging from 2.0 to 6.1 percent). During the period, computer programmers had a similar unemployment rate compared with the rate for all S&E occupations, but greater volatility (ranging from 1.2 to 6.5 percent). The most recent recession in 2002 appears to have had a strong impact on S&E employment, with the differential between S&E and general unemployment falling to only 1.9

[8]To maximize annual sample size from the Current Population Survey (CPS) without using multiple records for the same individuals (due to CPS' longitudinal sample design), only records from merged outgoing rotation groups were used. This may result in slightly different unemployment estimates than would be derived from an average of monthly unemployment.

Figure 3-7
Unemployment rate, by occupation: 1983–2002



SOURCES: U.S. Decennial Census Public Use Microdata Samples, 1980 and 1990; and National Bureau of Economic Research's Merged Outgoing Rotation Group files from the Bureau of Labor Statistics' Current Population Survey. See appendix table 3-8.

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percentage points, compared with 6.9 percentage points in 1983 (figure 3-7).[9] This may be due to the unusually strong reductions in research and development in the information and related technology sectors (see chapter 4).

The 1999 unemployment rate among the approximately 3.5 million college-educated individuals with S&E occupations in the labor force reached only 1.6 percent, or 56,000 individuals, compared with 4.4 percent for the U.S. labor force as a whole and 1.9 percent for all professional specialty workers (table 3-7).[10] Unemployment for college graduates working in S&E occupations dropped steadily from 1993, when it stood at 2.6 percent, to 1999. In the latter year, physical scientists had the highest unemployment rate (1.9 percent), and computer scientists and mathematicians, the lowest (1.2 percent). By degree level, 1.6 percent of S&E bachelor's degree recipients and master's degree recipients were unemployed, compared with 1.2 percent of doctorate holders.

Figure 3-8 compares unemployment rates over career cycles for bachelor's degree holders and doctorate holders in 1993 and in 1999. Looking at field of degree rather than occupation includes both individuals who might have left an S&E occupation for negative economic reasons and individuals who moved into other careers due to more positive factors. The generally stronger 1999 labor market had its greatest effect on bachelor's degree holders: for individuals at every point in their careers, the unemployment rate dropped by about 2 percentage points between 1993 and 1999. Although labor market conditions had a lesser effect on doctorate holders' unemployment rates, significant reductions in unemployment rates between 1993 and 1999 did occur for those individuals at both the beginning and the end of their careers.

Similarly, labor market conditions from 1993 to 1999 had a greater effect on the portion of bachelor's degree holders who said they were working involuntarily out of the field (IOF) of their highest degree than on doctorate holders (figure 3-9). However, the greatest differences in IOF rates for bachelor's degree holders occurred not at the beginning and end of their careers, but in midcareer. For doctorate holders, IOF rates changed little either between 1993 and 1999 or throughout most of their careers. The decline in IOF rates for the oldest doctorate holders may partially reflect lower

Table 3-7
Unemployment rate for individuals in S&E occupations: 1993 and 1999
(Percent)

Occupation	1993	1999
All S&E occupations	2.6	1.6
Engineers	3.4	1.8
Life and related scientists	1.7	1.3
Mathematical/computer scientists	1.9	1.2
Physical and related scientists	2.8	1.9
Social and related scientists	1.6	1.4

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993 and 1999. See appendix table 3-7.

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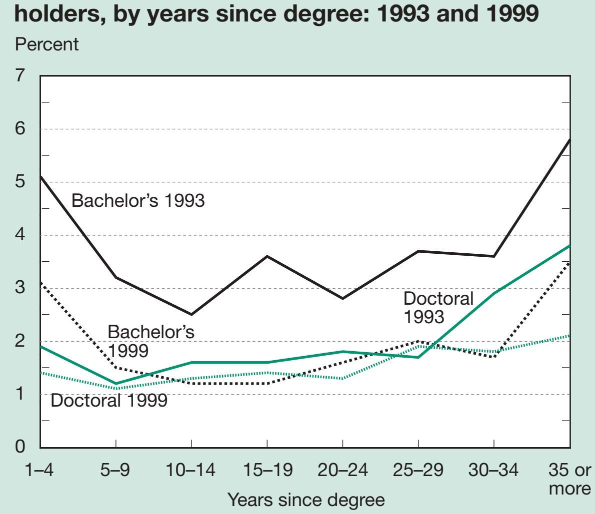
Figure 3-8
Unemployment rate for S&E highest degree holders, by years since degree: 1993 and 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993 and 1999.

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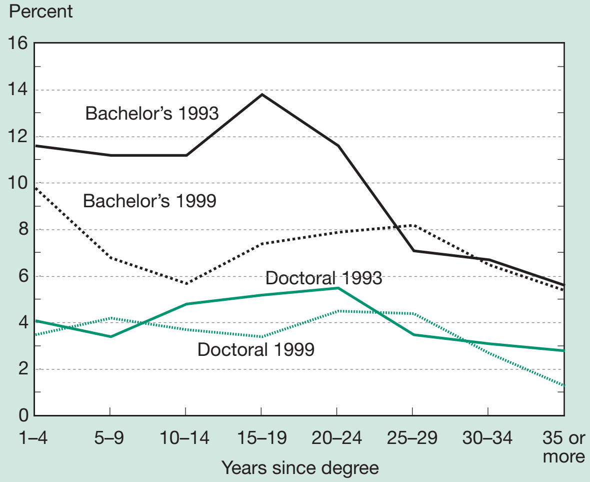
[9]A large part of the narrowing of this difference is due to the general decline in unemployment over this period.

[10]The unemployment rate is the ratio of individuals who are unemployed and seeking employment to the total labor force (i.e., those who are employed plus those who are unemployed and seeking employment). Individuals not in the labor force (i.e., individuals who are unemployed and not seeking employment) are excluded from the denominator.

Figure 3-9
Involuntarily-out-of-field rate of S&E highest degree holders, by years since degree: 1993 and 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993 and 1999.

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retirement rates for individuals working in their fields. Taken together with the unemployment patterns shown in figure 3-8, this finding implies that more highly educated S&E workers are less vulnerable to changes in economic conditions than individuals who hold only bachelor's degrees.

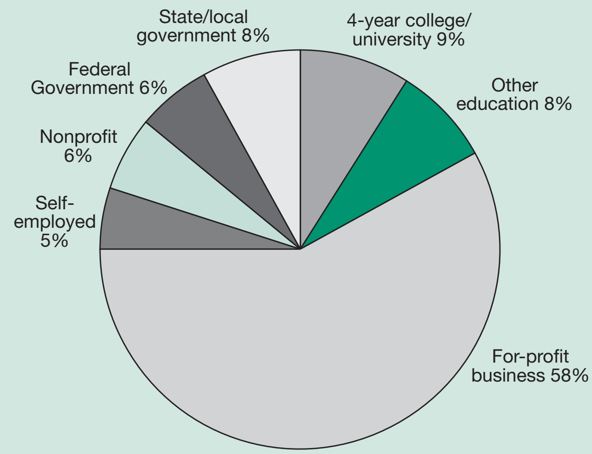
Employment Sectors

The private, for-profit sector is by far the largest provider of S&E employment. In 1999, approximately 73 percent of individuals working as scientists and engineers who had bachelor's degrees and 62 percent of persons who had master's degrees worked for private, for-profit companies. However, the majority of individuals with doctorates (51 percent) worked in the academic sector. Sectors that employ fewer S&E workers include educational institutions other than 4-year colleges and universities, nonprofit organizations, and state or local government agencies (appendix table 3-9).

The percentage of scientists and engineers employed in private, for-profit industry varies greatly for different S&E occupations. Although slightly more than three-fourths of both mathematical/computer scientists and engineers (76 and 78 percent, respectively) worked in this sector in 1999, only about one-fourth (27 percent) of life scientists and one-fifth (19 percent) of social scientists did so. Educational institutions employed the largest percentages of life scientists (48 percent) and social scientists (45 percent) (appendix table 3-9). (See sidebar, "Educational Distribution of S&E Workers.")

A similar pattern appears when looking at S&E degree holders, regardless of whether they work in S&E occupations (figures 3-10 and 3-11). For-profit business employs

Figure 3-10
Employment sector of S&E degree holders: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-11.

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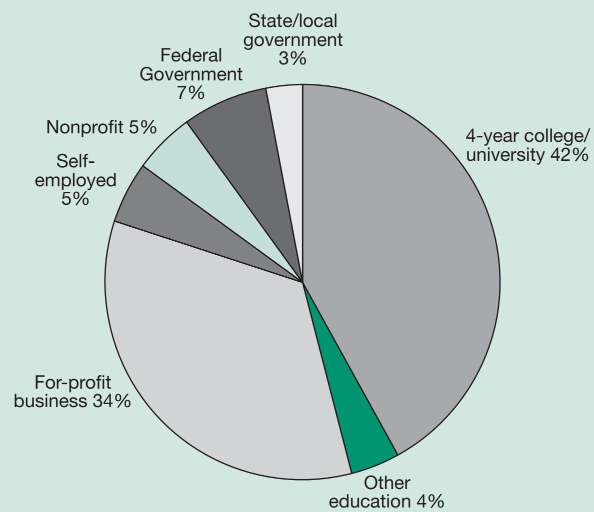
Figure 3-11
Employment sector of S&E doctorate holders: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-11.

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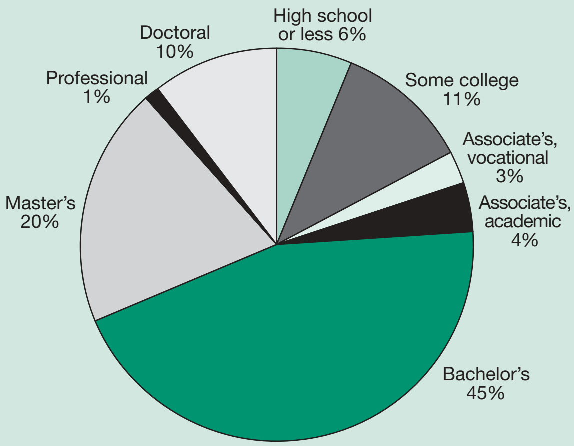
58 percent of all individuals whose highest degree is in S&E, including 34 percent of S&E doctorate holders. Four-year colleges and universities are a more important employer for S&E doctorate holders (42 percent). However, it should be noted that this figure includes a variety of employment types other than tenure track; only 27.6 percent of S&E doctorate holders in the labor force are employed in tenured or tenure-track positions (See sidebar, "Who Performs Research and Development?")

Educational Distribution of S&E Workers

Discussions of the science and engineering workforce often focus on individuals who hold doctorates. However, Current Population Survey data on the educational achievement of individuals working in S&E occupations outside academia in 2000 indicate that only 10.9 percent had doctorates (figure 3-12). In 2000, more than two-thirds of individuals working in nonacademic S&E occupations had bachelor's degrees (47 percent) or master's degrees (21 percent).

Figure 3-12
Educational distribution of individuals in nonacademic S&E occupations: 2000



SOURCE: U.S. Bureau of the Census, Current Population Survey, 2000.

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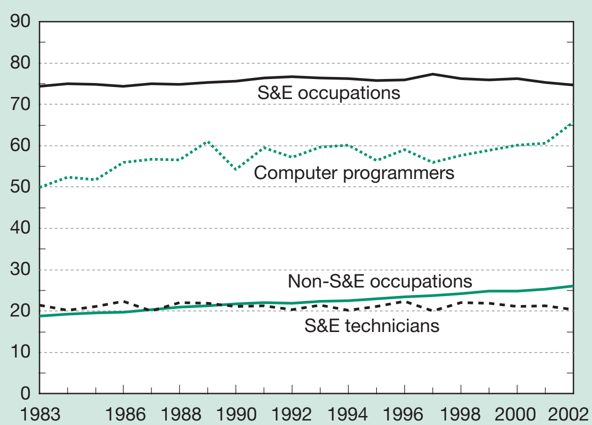
Almost one-fourth of individuals working in S&E occupations had not earned a bachelor's degree. Although technical issues of occupational classification may account for the size of the nonbaccalaureate S&E workforce, it is also true that many individuals who have not earned a bachelor's degree do enter the labor force with marketable technical skills from technical or vocational school training (with or without earned associate's degrees), college courses, and on-the-job training. In information technology, and to some extent in other occupations, employers frequently use certification exams, without reference to formal degrees, to judge skills.

From 1983 to 2002, the proportion of individuals in the S&E workforce without college degrees remained relatively constant. Among individuals working in S&E technician occupations the proportion with college degrees also remained nearly constant, at approximately 21 percent. In contrast, the proportion of individuals with college degrees among all workers in non-S&E occupations rose from 19 to 26 percent. The occupation of computer programmer, a non-S&E occupation of particular interest in discussions of the S&E labor force, increased its percentage of individuals with college degrees from 50 to 66 percent (figure 3-13).

Figure 3-13
Individuals with at least bachelor's degree, by selected occupation: 1983–2002



NOTE: Data before 1992 are based on individuals who had at least 16 years of education.

SOURCES: U.S. Decennial Census Public Use Microdata Samples, 1980 and 1990; National Bureau of Economic Research's Merged Outgoing Rotation Group files from the Bureau of Labor Statistics' Current Population Survey. See appendix table 3-10.

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Salaries

In 1999, bachelor's degree holders employed in S&E occupations had a median annual salary of $59,000; master's degree holders, $64,000; and doctorate holders, $68,000 (table 3-8 and appendix table 3-12).

From 1993 to 1999, median salaries for individuals employed in S&E occupations rose about 25 percent in current dollars. Computer scientists and mathematicians experienced the largest salary growth (37 percent), followed by engineers (30 percent). By degree level, median salaries for bachelor's degree recipients rose by 31 percent, followed by master's degree recipients at 28 percent.

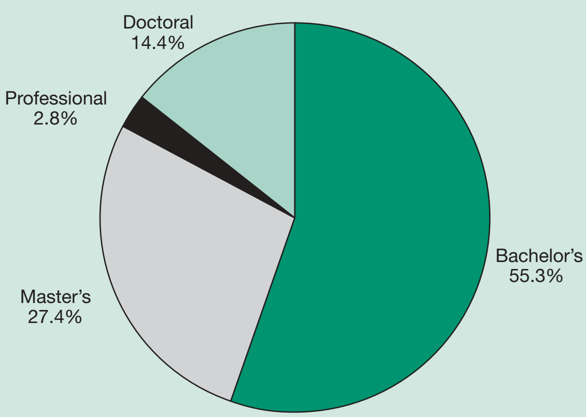
Education produces far more dramatic effects on the "tails" of the distribution (the proportion with either very high or very low earnings) than on median earnings. In 1999, 5 percent of S&E bachelor's degree holders had salaries greater than $100,000, compared with 16 percent of doctorate holders. Similarly, 21 percent of bachelor's degree holders earned less than $30,000, compared with 5 percent of doctorate holders. The latter figure is inflated due to the inclusion of postdocs. (The Survey of Doctorate Recipients defines postdoc as a temporary position awarded in academia, industry, or government for the primary purpose of receiving additional research training.)

Who Performs Research and Development?

Although individuals with science and engineering degrees use their acquired knowledge in various ways (e.g., teaching, writing, evaluating, and testing), they show a special interest in research and development. Figure 3-14 shows the distribution of individuals with S&E degrees by level of degree who report R&D as a major work activity (defined as the activity involving the greatest, or second greatest, number of work hours from a list of 22 possible work activities). Individuals with doctorates constitute only 6 percent of all individuals with S&E degrees but represent 14.4 percent of individuals who report R&D as a major work activity. However, the majority of S&E degree holders who report R&D as a major work activity have only bachelor's degrees (55.3 percent). An additional 27.4 percent have master's degrees and 2.8 percent have professional degrees, mostly in medicine. Figure 3-15 shows the distribution of individuals with S&E degrees, by field of highest degree, who reported R&D as a major work activity. Individuals with engineering degrees constitute almost one-third (31.7 percent) of the total. Note that 17.9 percent did not earn their highest degrees in S&E fields; in most cases, a person in this group has an S&E bachelor's degree and a higher degree in a professional field such as business, medicine, or law.

Figure 3-16 shows the percentages of S&E doctorate holders reporting R&D as a major work activity by field of degree and by years since receipt of doctorate. Individuals working in physical sciences and engineering report the highest R&D rates over their career cycles, with the lowest R&D rates in social sciences. Although the percentage of doctorate holders engaged in R&D activities declines as time since receipt of degree increases, it remains greater than 50 percent in all fields except social sciences up to 25 years since receipt of degree. This decline may reflect a normal career process of movement into management or other career interests. It may also reflect, even within nonmanagement positions, increased opportunity and the ability of more experienced scientists to perform functions involving the interpretation and use, as opposed to the creation of, scientific knowledge.

Figure 3-14
Distribution of S&E-degreed workers with R&D as major work activity, by degree level: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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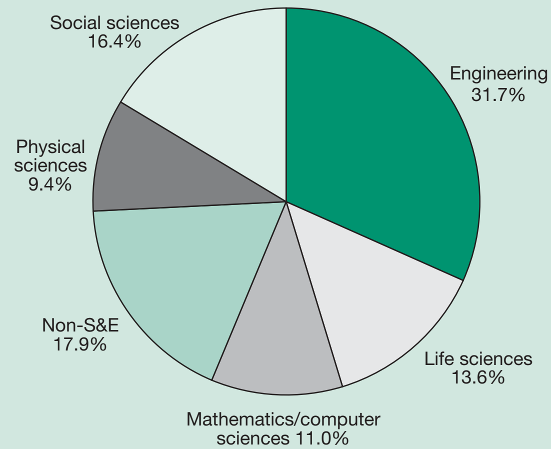
Figure 3-15
Distribution of S&E-degreed workers with R&D as major work activity, by field of highest degree: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT),1999.

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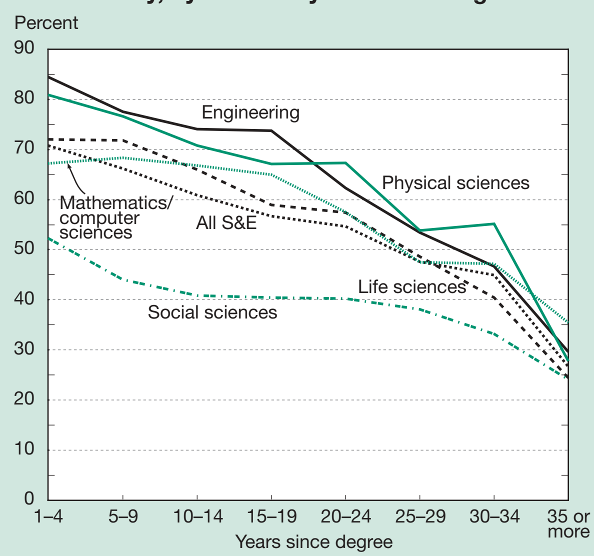
Figure 3-16
S&E doctorate holders engaged in R&D as major work activity, by field and years since degree: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Table 3-8
Median annual salary of U.S. individuals in S&E occupations, by highest degree: Selected years, 1993–99
(Dollars)

Highest degree	1993	1995	1997	1999
All S&E	48,000	50,000	55,000	60,000
Bachelor's	45,000	48,000	52,000	59,000
Master's	50,000	53,500	59,000	64,000
Doctoral	55,000	58,000	62,000	68,000

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993–99. See appendix table 3-12.

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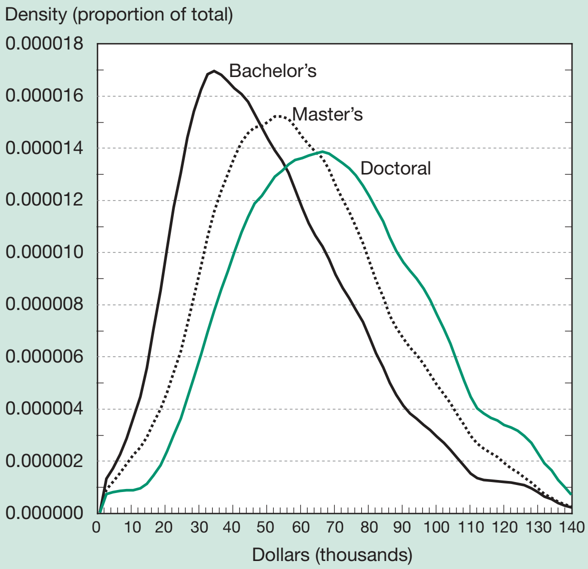
Figure 3-17
Salary distribution of S&E degree holders employed full time, by degree level: 1999



NOTE: Salary distribution is smoothed using kernel density techniques.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Figure 3-17 illustrates the distribution of salaries earned by individuals with S&E degrees.

Women and Minorities in S&E

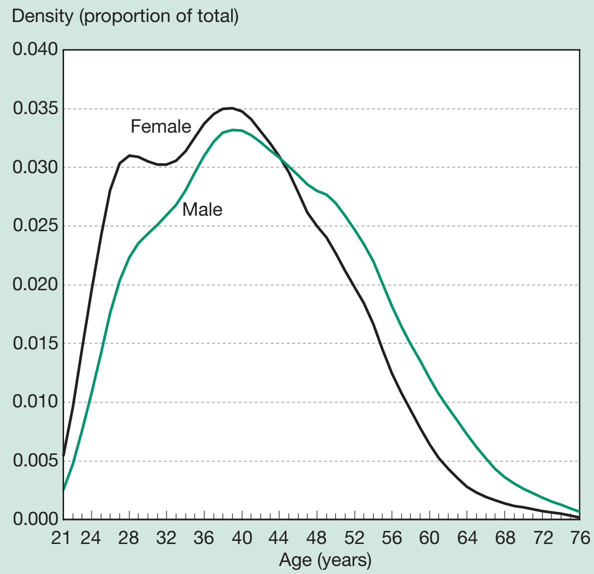
Demographic factors for women and minorities (such as age and years in the workforce, field of S&E employment, and highest degree level achieved) influence employment patterns. Demographically, men differ from women, and minorities differ from nonminorities; thus, their employment patterns also are likely to differ. For example, because larger numbers of women and minorities entered S&E fields only recently, women and minority men generally are younger than non-Hispanic white males and have fewer years of experience (appendix table 3-13). Age and stage in career in turn influence such employment-related factors as salary, position, tenure, and work activity. In addition, employment patterns vary by field (see sidebar, "Growth of Representation of Women, Minorities, and the Foreign Born in S&E Occupations") and these differences influence S&E employment, unemployment, salaries, and work activities. Highest degree earned, yet another important influence, particularly affects primary work activity and salary.

Representation of Women in S&E

Women constituted almost one-fourth (24.7 percent) of the college-educated workforce in S&E occupations but close to half (46 percent) of the total U.S. workforce in 1999. Although changes in the NSF/SRS surveys do not permit analysis of long-term trends in employment, short-term trends indicate an increase in female doctorate holders employed in S&E. In 1993, women constituted 20 percent of doctorate holders in S&E occupations in the United States; in 1995, 22 percent; in 1997, 23 percent; and in 1999, 24 percent.

Age Distribution and Experience. Differences in age and related time spent in the workforce account for many of the differences in employment characteristics between men and women. On average, women in the S&E workforce are younger than men (figure 3-18): 50 percent of women and 36 percent of men employed as scientists and engineers in 1999 received their degrees within the past 10 years. The difference is even more profound at the doctorate level,

Figure 3-18
Age distribution of individuals in S&E occupations, by sex: 1999



NOTE: Age distribution is smoothed using kernel density techniques.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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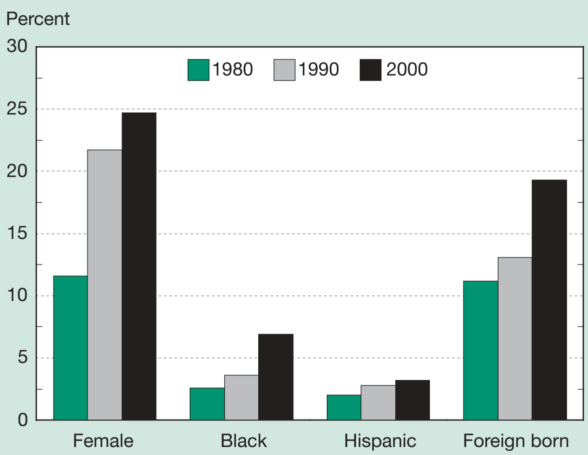
Growth of Representation of Women, Minorities, and the Foreign Born in S&E Occupations

A longer view of changes in the sex and ethnic composition of the science and engineering workforce can be achieved by examining data on college-educated individuals in nonacademic S&E occupations from the 1980 Census, the 1990 Census, and the March 2000 Current Population Survey (figure 3-19). In 2000, the percentage of historically underrepresented groups in S&E occupations remained lower than the percentage of those groups in the total college-educated workforce:

- Women made up 24.7 percent of the S&E workforce and 48.6 percent of the college-degreed workforce.
- Blacks made up 6.9 percent of the S&E workforce and 7.4 percent of the college-degreed workforce.
- Hispanics made up 3.2 percent of the S&E workforce and 4.3 percent of the college-degreed workforce.

However, since 1980, share of S&E occupations has more than doubled for blacks (2.6 to 6.9 percent) and women (11.6 to 24.7 percent). Hispanic representation also increased between 1980 and 2000, albeit at a lower rate (2.0 to 3.2 percent). The percentage of foreign-born college graduates in S&E jobs increased from 11.2 percent in 1980 to 19.3 percent in 2000.

Figure 3-19
College graduates in nonacademic S&E occupations, by sex and race/ethnicity: 1980, 1990, and 2000



SOURCES: U.S. Decennial Census Public Use Microdata Samples, 1980 and 1990; and National Bureau of Economic Research's Merged Outgoing Rotation Group files from the Bureau of Labor Statistics' Current Population Survey.

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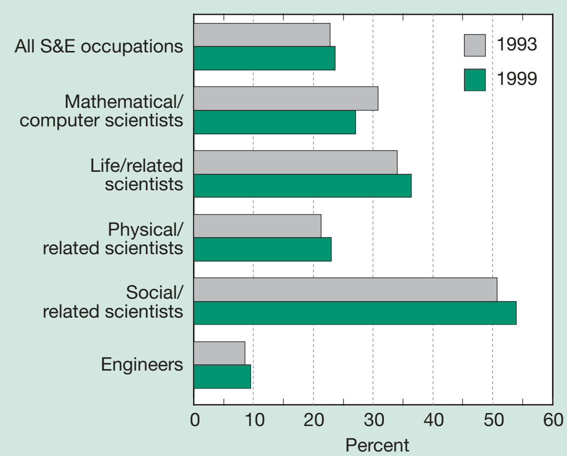
where there is a much greater concentration of female doctorate holders in their late thirties. One clear consequence of this age distribution is that a much larger proportion of male scientists and engineers at all degree levels, but particularly at the doctorate level, will reach traditional retirement age during the next decade. This alone will have a significant effect upon gender ratios, and also perhaps on the numbers of female scientists in positions of authority as the large proportion of female doctorate holders in their late thirties moves into their forties.

S&E Occupation. Representation of men and women also differs according to field of occupation. For example, in 1999, women constituted 54 percent of social scientists, compared with 23 percent of physical scientists and 10 percent of engineers (figure 3-20). Within engineering, female representation is greater in some fields than in others. For example, women constituted 15 percent of chemical and industrial engineers, but only 6 percent of aerospace, electrical, and mechanical engineers. Since 1993, the percentage of women in most S&E occupations has gradually increased. However, in mathematics and computer sciences, the percentage of women declined about 4 percentage points between 1993 and 1999 (figure 3-20 and appendix table 3-13).

Educational Background. In many occupational fields, male scientists generally have higher education levels than female scientists. In the science workforce as a whole, 16 percent of women and 20 percent of men have achieved doctorate degrees. In biology, those figures stand at 26 percent of women and 40 percent of men; in chemistry, 14 percent of women and 27 percent of men; and in psychology, 22 percent of women and 42 percent of men. Engineering figures, however, differ much less, as about 5 percent of women and 6 percent of men have doctorates (NSF/SRS 1999c). Differences

Figure 3-20
Female employment in S&E occupations, by broad occupation: 1993 and 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993 and 1999. See appendix table 3-13.

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in highest degree achieved influence differences in type of work performed, employment in S&E jobs, and salaries.

Labor Force Participation, Employment, and Unemployment. Male scientists and engineers are more likely to be in the labor force, employed full time, and/or employed in their field of highest degree. Women are more likely to be out of the labor force, employed part time, and/or employed involuntarily outside their fields (IOF). Many of these differences are due to differences in age distributions of men and women.

Unemployment rates for men and women in S&E occupations were similar in 1999: 1.5 percent of men and 1.8 percent of women were unemployed. By comparison, the unemployment rate in 1993 was 2.8 percent for men and 2.2 percent for women (table 3-9 and appendix table 3-14)

Salaries. In 1999, female scientists and engineers earned a median annual salary of $50,000, about 22 percent less than the median annual salary earned by male scientists and engineers ($64,000). Between 1993 and 1999, median annual salaries for female scientists and engineers increased by 25 percent, compared with an increase of 28 percent for their male counterparts (table 3-10). Several factors may contribute to these salary differentials. Women more often work in educational institutions, in social science occupations, and in nonmanagerial positions; they also tend to have less experience. In 1999, among scientists and engineers in the workforce who have held their degrees for 5 years or less, women earned an average median annual salary that was 83 percent of that earned by men.

Salary differentials varied by broad field. In computer sciences and mathematics occupations in 1999, women earned approximately 12 percent less than men; in life science occupations, the difference stood at 23 percent. Women also earned their highest and lowest median salaries in those two occupation groups, $58,000 in computer sciences and mathematics and $39,000 in life sciences (figure 3-21 and appendix table 3-15).

Table 3-9
Unemployment rate for individuals in S&E occupations, by sex and race/ethnicity: 1993 and 1999
(Percent)

Sex or race/ethnicity	1993	1999
All with S&E occupations	2.6	1.6
Male	2.7	1.5
Female	2.1	1.8
White	2.4	1.5
Asian/Pacific Islander	4.0	1.5
Black	2.8	2.6
Hispanic	3.5	1.8

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993 and 1999. See appendix table 3-14.

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Table 3-10
Median annual salary of individuals employed in S&E occupations, by sex and race/ethnicity: Selected years, 1993–99
(Dollars)

Sex or race/ethnicity	1993	1995	1997	1999
All with S&E occupations	48,000	50,000	55,000	60,000
Male	50,000	52,000	58,000	64,000
Female	40,000	42,000	47,000	50,000
White	48,000	50,500	55,000	61,000
Asian/Pacific Islander	48,000	50,000	55,000	62,000
Black	40,000	45,000	48,000	53,000
Hispanic	43,000	47,000	50,000	55,000

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1993–99. See appendix table 3-15.

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Representation of Racial and Ethnic Minorities in S&E

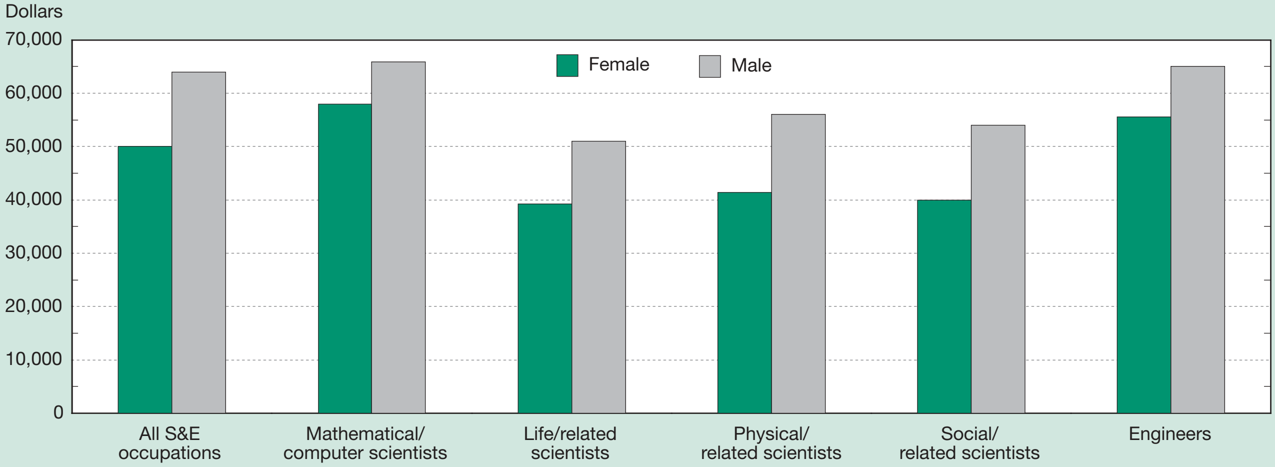
With the exception of Asian/Pacific Islanders, minorities represent only a small proportion of scientists and engineers in the United States.[11] (Although Asian/Pacific Islanders constitute only 4 percent of the U.S. population, they accounted for 11 percent of scientists and engineers in 1999.) Collectively, blacks, Hispanics, and other ethnic groups (the latter includes American Indian/Alaskan Natives) constituted 24 percent of the total U.S. population and 7 percent of the total S&E workforce in 1999.[12] Blacks and Hispanics each accounted for about 3 percent of scientists and engineers, and other ethnic groups represented less than 0.5 percent (appendix table 3-16). Between 1993 and 1999, the portion of Asian/Pacific Islanders in the S&E workforce increased by about 2 percentage points, whereas the portion of blacks, Hispanics, and other ethnic groups did not change significantly.

Age Distribution. As in the case of women, underrepresented racial and ethnic minorities are much younger than non-Hispanic whites in the same S&E occupations (figure 3-22), and this is even truer for doctorate holders in S&E occupations. In the near future, a much greater proportion of non-Hispanic white doctorate holders in S&E occupations will be reaching traditional retirement ages compared

[11]The term *underrepresented minorities* includes three groups that have a smaller representation in science and engineering than in the overall population: blacks, Hispanics, and American Indian/Alaskan Natives. (In accordance with Office of Management and Budget guidelines, the racial and ethnic groups described in this section are identified as white and non-Hispanic, Asian/Pacific Islander, black and non-Hispanic, Hispanic, and American Indian/Alaskan Native.)

[12]The S&E fields in which blacks, Hispanics, and American Indian/Alaskan Natives earn their degrees influence their participation in the S&E labor force. Disproportionately more blacks, Hispanics, and American Indian/Alaskan Natives earn degrees in social sciences and work in social service positions (such as social worker and clinical psychologist), which the NSF/SRS defines as non-S&E occupations. See NSF/SRS 1999a and appendix table 3-1 for the NSF/SRS classification of S&E fields.

Figure 3-21
Median annual salary of employed scientists and engineers, by broad occupation and sex: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-15.

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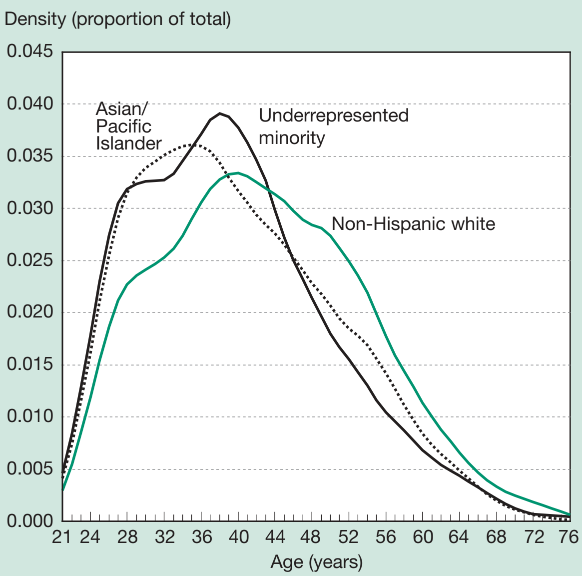
Figure 3-22
Age distribution of individuals in S&E occupations, by race/ethnicity: 1999



NOTE: Age distribution is smoothed using kernel density techniques.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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with underrepresented racial and ethnic doctorate holders. Indeed, unlike the distribution of ages of male and female doctorate holders shown in figure 3-18, figure 3-22 shows that the slope of the right-hand side of the age distribution is far steeper for non-Hispanic whites. This implies a more rapid increase in the numbers retiring or otherwise leaving S&E employment. It should also be noted that Asian/Pacific Islander doctorate holders in S&E occupations (measured by race and not by place of birth) are on average the youngest racial/ethnic group.

S&E Occupation. Asian/Pacific Islander, black, and American Indian/Alaskan Native scientists and engineers tend to work in different fields than their white and Hispanic counterparts. Fewer Asian/Pacific Islanders work in social sciences than in other fields. In 1999, they constituted 4 percent of social scientists, but more than 11 percent of engineers and more than 13 percent of individuals working in mathematics and computer sciences. More black scientists and engineers work in social sciences and in computer sciences and mathematics than in other fields. In 1999, blacks constituted approximately 5 percent of social scientists, 4 percent of computer scientists and mathematicians, 3 percent of physical scientists and engineers, and 2 percent of life scientists. Other ethnic groups (which includes American Indian/Alaskan Natives) work predominantly in social and life sciences, accounting for 0.4 percent of social and life scientists and 0.3 percent or less of scientists in other fields in 1999. Hispanics appear to have a more even representation across all fields, constituting approximately 2.5 to 4.5 percent of scientists and engineers in each field (appendix table 3-13).

Educational Background. The educational achievement of scientists and engineers also differs among racial and ethnic groups. A bachelor's degree is more likely to be the highest degree achieved for black and Hispanic scientists and engineers than for white or Asian/Pacific Islander scientists and engineers—in 1999, a bachelor's degree was the highest degree achieved for 61 percent of black scientists and engineers in the U.S. workforce compared with 56 percent of all scientists and engineers (appendix table 3-13).

Labor Force Participation, Employment, and Unemployment. Labor force participation rates vary by race and ethnicity. Minority scientists and engineers are more likely than others to be in the labor force (either employed or seeking employment). In 1999, participation rates in the labor force ranged between 87 and 93 percent for Asian/Pacific Islander, black, Hispanic, and American Indian/Alaskan Native scientists and engineers, compared with 86 percent for white scientists and engineers (appendix table 3-14). Age and related retirement rates may contribute to these differences. On average, white scientists and engineers are older than scientists and engineers in other racial and ethnic groups: 28 percent of white scientists and engineers were age 50 or older in 1999, compared with 15–20 percent of Asian/Pacific Islanders, blacks, and Hispanics (appendix table 3-13). For individuals in similar age groups, the labor force participation rates of white and minority scientists and engineers are similar.

Although more minority individuals remain in the labor force, they also are more likely to be unemployed. In 1999, the unemployment rate of white scientists and engineers was somewhat lower than the rate for other racial and ethnic groups. The unemployment rate for both whites and Asian/Pacific Islanders stood at 1.5 percent, compared with 1.8 percent for Hispanics and 2.6 percent for blacks. In 1993, the unemployment rate for whites reached 2.4 percent, compared with 4.0 percent for Asian/Pacific Islanders, 3.5 percent for Hispanics, and 2.7 percent for blacks (table 3-9).

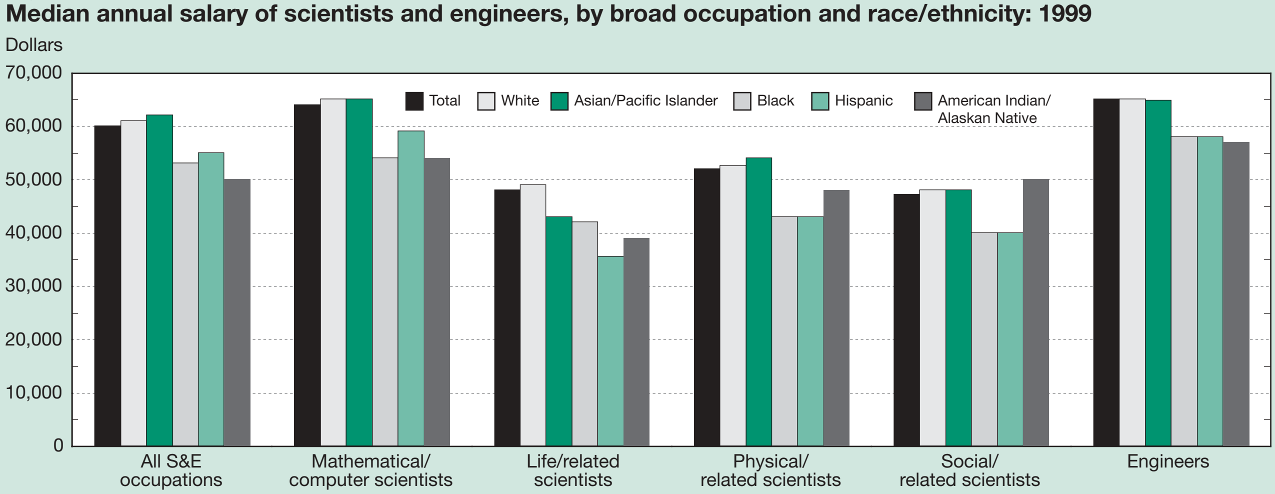
The differences in 1999 unemployment rates are evident within S&E fields as well as for S&E as a whole. For example, the unemployment rate for white engineers was 1.8 percent; for black and Asian/Pacific Islander engineers, it was 2.3 and 1.8 percent, respectively (appendix table 3-14).

Salaries. Salaries for individuals in S&E occupations vary among the different racial and ethnic groups. In 1999, white and Asian/Pacific Islanders in S&E occupations earned similar median annual salaries of $61,000 and $62,000, respectively, compared with $55,000 for Hispanics, $53,000 for blacks, and $50,000 for other ethnic groups, including American Indian/Alaskan Natives (figure 3-23 and table 3-10). These salary patterns are similar to rates recorded in 1993. However, age, field of degree, and sector of employment all influence differences.

Across occupational fields and age categories, the median annual salaries of individuals in S&E occupations by race and ethnicity do not follow a consistent pattern. For example, in 1999, the median annual salary of 20–29-year-old engineers with bachelor's degrees ranged from $35,000 for American Indian/Alaskan Natives to $46,000 for Hispanics. Among individuals between the ages of 40 and 49, the median salary ranged from $60,000 for Asian/Pacific Islanders and American Indian/Alaskan Natives to $70,000 for whites.

In 1999, the median annual salary of engineers with bachelor's degrees who had received their degrees within the past 5 years reached $45,000 for all ethnicities except individuals in the "other" category (including American Indian/Alaskan Natives) (appendix table 3-15). Among engineers who had received their degrees 20–24 years previously, the median annual salary reached approximately $70,000 for all ethnicities. (See sidebar, "Salary Differentials")

Figure 3-23
Median annual salary of scientists and engineers, by broad occupation and race/ethnicity: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-15.

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Salary Differentials

Differences in salaries of women and ethnic minorities are often used as indicators of progress that individuals in such groups are making in science and engineering. Indeed, as shown in table 3-11, these salary differences are substantial when comparing all individuals with S&E degrees by level of degree: in 1999, women with S&E bachelor's degrees had full-time mean salaries that were 35.1 percent less than those of men with S&E bachelor's degrees.* Blacks, Hispanics, and individuals in other underrepresented ethnic groups with S&E bachelor's degrees had full-time salaries that were 21.9 percent less than those of non-Hispanic whites and Asian/Pacific Islanders with S&E bachelor's degrees.† These raw differences in salary are lower but still large at the doctorate level (–25.8 percent for women and –12.7 percent for underrepresented ethnic groups). In contrast, foreign-born individuals with U.S. S&E degrees have slightly higher salaries than U.S. natives at the bachelor's and master's levels, but their salaries at the doctorate level show no statistically significant differences from those of natives.

However, differences in average age, work experience, fields of degree, and other characteristics make direct comparison of salary and earnings statistics difficult. Generally, engineers earn a higher salary than social scientists, and newer employees earn less than those with more experience. One common statistical method that can be used to look simultaneously at salary and other differences is regression analysis.‡ Table 3-11 shows estimates of salary differences for different groups after controlling for several individual characteristics.

Although this type of analysis can provide insight, it cannot give definitive answers to questions about the openness of S&E to women and minorities for many reasons. The most basic reason is that no labor force survey ever captures all information on individual skill sets, personal background and attributes, or other characteristics that may affect compensation. In addition, even characteristics that are measurable are not distributed randomly among individuals. An individual's choice of degree field and occupation, for example, will reflect in part the real and perceived opportunities for that individual. The associations of salary differences with individual characteristics, not field choice and occupation choice, are examined here.

Table 3-11
Estimated salary differentials of individuals with S&E degrees, by individual characteristics and degree level: 1999
(Percent)

Characteristic	Bachelor's	Master's	Doctoral
Female versus male	–35.1	–28.9	–25.8
Controlling for age and years since degree	–27.2	–25.5	–16.7
Plus field of degree	–14.0	–9.6	–10.3
Plus occupation and employer characteristics	–11.0	–8.0	–8.4
Plus family and personal characteristics	–10.2	–7.4	–7.4
Plus gender-specific marriage and child effects	–4.6	NS	–3.1
Black, Hispanic, and other versus white and Asian/Pacific Islander	–21.9	–19.3	–12.7
Controlling for age and years since degree	–13.0	–14.6	–4.7
Plus field of degree	–8.6	–6.7	–2.2
Plus occupation and employer characteristics	–7.3	–4.2	NS
Plus family and personal characteristics	–5.7	–3.3	NS
Foreign born with U.S. degree versus native born	3.7	9.5	NS
Controlling for age and years since degree	6.7	12.4	7.8
Plus field of degree	NS	NS	NS
Plus occupation and employer characteristics	NS	–2.8	–2.8
Plus family and personal characteristics	NS	–3.1	–2.7

NS not significantly different from zero at $p = .05$

NOTE: Linear regressions on ln(full-time annual salary).

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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*For consistency with the other salary differences shown in table 3-11, these salary differences were generated from regressions of ln (full-time annual salary) on just a dummy variable for membership in the group being examined. This corresponds to differences in the geometric mean of salary, not to differences in median salary as reported elsewhere in this chapter.

†"Underrepresented ethnic group" as used here includes individuals who reported their race as black, Native American, or other, or who reported Hispanic ethnicity.

‡Specifically presented here are coefficients from linear regressions using the 1999 Scientists and Engineers Statistical Data System (SESTAT) data file of individual characteristics upon the natural log of reported full-time annual salary as of April 1999.

Effects of Age and Years Since Degree on Salary Differentials

Salary differences between men and women reflect to some extent the lower average ages of women with degrees in most S&E fields. Controlling for differences in age and years since degree reduces salary differentials for women compared with men by about one-fourth at the bachelor's degree level (to –27.2 percent) and by about one-third at the Ph.D. level (to –16.7 percent).[§]

When controlling for differences in age and years since degree, even larger drops in salary differentials are found for underrepresented ethnic minorities. Such controls reduce salary differentials of underrepresented minorities compared with non-Hispanic whites and Asian/Pacific Islanders by more than two-fifths at the bachelor's degree level (to –13.0 percent) and by nearly two-thirds at the doctorate level (to –4.7 percent).

Because foreign-born individuals in the labor force who have S&E degrees are somewhat younger on average than natives, controlling for age and years since degree moves their salary differentials in a positive direction—in this case, making an initial earnings advantage over natives even larger—to 6.7 percent for foreign-born individuals with S&E bachelor's degrees and to 7.8 percent for those with S&E doctorates.

Effects of Field of Degree on Salary Differentials

Controlling for field of degree and for age and years since degree reduces the estimated salary differentials for women with S&E degrees to –14.0 percent at the bachelor's level and to –10.3 percent at the doctorate level.[||] These reductions generally reflect the greater concentration of women in the lower-paying social and life sciences as opposed to engineering and computer sciences. As noted above, this identifies only one factor associated with salary differences and does not speak to why there are differences between males and females in field of degree or whether salaries are affected by the percentage of women studying in each field.

Field of degree is also associated with significant estimated salary differentials for underrepresented ethnic groups. Controlling for field of degree further reduces salary differentials to –8.6 percent for those individuals with S&E bachelor's degrees and to –2.2 percent for those individuals with S&E doctorates. Thus, age, years since degree, and field of degree are associated with almost all doctorate-level salary differentials for underrepresented ethnic groups.

Compared with natives at any level of degree, foreign-born individuals with S&E degrees show no statistically significant salary differences when controlling for age, years since degree, and field of degree.

Effects of Occupation and Employer on Salary Differentials

Obviously, occupation and employer characteristics affect compensation.[#] Academic and nonprofit employers typically pay less for the same skills than employers pay in the private sector, and government compensation falls somewhere between the two groups. Other factors affecting salary are relation of work performed to degree earned, whether the person is working in S&E, whether the person is working in R&D, employer size, and U.S. region. However, occupation and employer characteristics may not be determined solely by individual choice, for they may also reflect in part an individual's career success.

When comparing women with men and underrepresented ethnic groups with non-Hispanic whites and Asian/Pacific Islanders, controlling for occupation and employer reduces salary differentials only slightly beyond what is found when controlling for age, years since degree, and field of degree. For foreign-born individuals compared with natives, controls for occupation and employer characteristics also produce only small changes in estimated salary differentials, but in this case, the controls result in small negative salary differentials at the master's (–2.8 percent) and doctorate (–2.8 percent) levels.

Effects of Family and Personal Characteristics on Salary Differentials

Marital status, children, parental education, and other personal characteristics are often associated with differences in compensation. Although these differences may indeed involve discrimination, they may also reflect many subtle individual differences that might affect work productivity.[**] As with occupation and employer characteristics, controlling for these characteristics changes salary differentials only slightly at any degree level. However, most of the remaining salary differentials for women disappear when the regression equations allow for the separate effects of marriage and children for each sex. Marriage is associated with higher salaries for both men and women, but has a larger positive association for men. Children have a positive association with salary for men but a negative association with salary for women.

[§]In the regression equation, this is the form: age, age^2, age^3, age^4; years since highest degree (YSD), YSD^2, YSD^3, YSD^4.

[||]Included were 20 dummy variables for NSF/SRS SESTAT field-of-degree categories (out of 21 S&E fields; the excluded category in the regressions was "other social science").

[#]Variables added here include 34 SESTAT occupational groups (excluding "other non-S&E"), whether individuals said their jobs were closely related to their degrees, whether individuals worked in research and development, whether their employers had less than 100 employees, and their employers' U.S. Census region.

[**]Variables added here include dummy variables for marriage, number of children in the household younger than 18, whether the father had a bachelor's degree, whether either parent had a graduate degree, and citizenship. Also, sex, nativity, and ethnic minority variables are included in all regression equations.

Labor Market Conditions for Recent S&E Graduates

The labor market activities of recent S&E graduates often serve as the most sensitive indicators of changes in the S&E labor market. This section looks at a number of standard labor market indicators for bachelor's and master's degree recipients, and also examines a number of other indicators that may apply only to recent S&E doctorate-recipients.

In general, recent graduates in S&E fields found good labor market conditions during the periods for which NSF/SRS survey data exist (April 1999 for bachelor's degree recipients and master's degree recipients, and April 2001 for doctorate-recipients). Between 1999 and 2001, the proportion of recent S&E doctorate-recipients obtaining tenure-track positions increased slightly and the number of individuals entering postdocs decreased slightly. Despite these changes, only about one-fifth of S&E doctorate-recipients hold tenure-track positions 4–6 years after receiving their degrees.

Bachelor's and Master's Degree Recipients

Recent recipients of S&E bachelor's and master's degrees form an important component of the U.S. S&E workforce, accounting for almost half of the annual inflow into S&E occupations.[13] Recent graduates' career choices and entry into the labor market affect the supply and demand for scientists and engineers throughout the United States. This section offers insight into labor market conditions for recent S&E graduates in the United States. Topics examined include graduate school enrollment rates, employment by level and field of degree, employment sectors, and median annual salaries.

Relation of Employment to School

In 1999, approximately one-fifth of 1997 and 1998 graduates who had earned either bachelor's or master's degrees were enrolled full time in school at some level. Students who had majored in physical and life sciences were more likely to be full-time students than were graduates with degrees in computer and information sciences and engineering (appendix table 3-17).

Relation of Employment to Level and Field of Degree

Job market success varies significantly by level and field of degree. Finding employment directly related to field of study serves as one measure of success. In 1999, over half of employed master's degree recipients but only one-fifth of employed bachelor's degree recipients worked in jobs closely related to the field of their highest degree. Among both master's and bachelor's degree recipients, more students who had received their degrees in either engineering or computer sciences and mathematics worked in their field of study compared with individuals who received degrees in other S&E fields, whereas students who had received degrees in social sciences were less likely than their counterparts in other S&E fields to have jobs directly related to their degrees.

Employment Sectors

The private, for-profit sector employs the majority of recent S&E bachelor's and master's degree recipients (table 3-12). In 1999, 63 percent of bachelor's degree recipients and 57 percent of master's degree recipients found employment with private, for-profit companies. The education sector employs the second largest group of recent S&E graduates and more master's degree recipients (12 percent) than bachelor's degree recipients (8 percent) found employment with 4-year colleges and universities. The Federal sector employed only 5 percent of recent S&E master's degree recipients and 4 percent of bachelor's degree recipients in 1999; more engineering graduates than science graduates found employment in the Federal sector. Other sectors that employed only small numbers of recent S&E graduates include educational institutions other than 4-year colleges and universities, nonprofit organizations, and state and local government agencies. Only very small percentages of engineering bachelor's and master's degree recipients (1 and 2 percent, respectively) were self-employed.

Employment and Career Paths

As one might expect, more S&E master's degree holders reported having a career-path job compared with S&E bachelor's degree holders. (*Career-path jobs* help graduates fulfill their future career plans.) Approximately three-fourths of all master's degree recipients and three-fifths of all bachelor's degree recipients held a career-path job in 1999. Graduates with degrees in computer and information sciences or in engineering were more likely to hold career-path jobs compared with graduates with degrees in other fields: about four-fifths of recent bachelor's and master's degree graduates in computer and information sciences and in engineering reported that they held career-path jobs.

Salaries

In 1999, recent (1–3 years since degree) bachelor's degree recipients with degrees in computer and information sciences earned the highest median annual salaries ($44,000) among all recent science graduates. For recent graduates with degrees in engineering, individuals receiving degrees in electrical/electronics, computer, and communications engineering earned the highest median annual salaries ($46,000). The same pattern held true for recent master's degree recipients: individuals receiving degrees in computer and information sciences earned the highest median annual salaries ($58,000) among science graduates. Among

[13]Much of the data for this section comes from the National Survey of Recent College Graduates. This survey collected information on the 1999 workforce status of 1997 and 1998 bachelor's and master's degree recipients in S&E fields. NSF/SRS has sponsored surveys of recent S&E graduates biennially since 1978.

Table 3-12
1997 and 1998 S&E bachelor's and master's degree recipients, by degree field and employment sector: 1999

		Employment sector						
		Education		Noneducation				
Degree and field	Employed	4-year college/ university	Other institution	Private for-profit company	Self-employed	Nonprofit organization	Federal Government	State/local government
	Thousands	Percent						
Bachelor's	539.2	8	10	63	1	7	4	7
Sciences	442.4	9	12	58	2	9	4	8
Engineering	96.7	4	1	86	<1	1	5	4
Master's	118.1	12	9	57	2	7	5	7
Sciences	80.6	15	12	48	3	10	4	9
Engineering	37.6	8	<1	78	1	1	8	4

NOTES: Employment sector refers to respondent's primary job on April 15, 1999. In this categorization, those working in 4-year colleges and universities or university-affiliated medical schools or research organizations were classified as "4-year college/university." Those working in elementary, middle, secondary, or 2-year colleges or other educational institutions were categorized as "other institution." Those reporting that they were self-employed but in an incorporated business were classified as "private for-profit company." For graduates with more than one eligible degree at the same level, the degree for which the graduate was sampled was used. Details may not add to totals because of rounding. Percents were calculated on nonrounded data.

SOURCE: National Science Foundation, Division of Science Resources Statistics, National Survey of Recent College Graduates, 1999.

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engineering graduates, individuals who received master's degrees in electrical/electronics, computer, and communications engineering earned the highest median annual salaries ($60,000) (appendix table 3-17).

Doctoral Degree Recipients

Analyses of labor market conditions for scientists and engineers holding doctorate degrees often focus on the ease or difficulty of beginning careers for recent doctoral degree recipients. Although a doctorate degree does create more career opportunities, both in terms of salary and type of employment, these opportunities come at the price of many years of foregone labor market earnings. Many doctorate holders also face an additional period of low earnings while completing a postdoc. In addition, some doctorate holders may not find themselves in the type of employment they desired while in graduate school.

Since the 1950s, the Federal Government has actively encouraged graduate training in S&E through numerous mechanisms. Ph.D. programs have served multiple facets of the national interest by providing a supply of more highly trained and motivated graduate students to aid university-based research. These programs have provided individuals with detailed, highly specialized training in particular areas of research, and paradoxically, through that same specialized training, generated a general ability to perform self-initiated research in more diverse areas.

The career aspirations of highly skilled individuals in general, and doctorate holders in particular, often cannot be measured through just salary and employment. Their technical and problem-solving skills make them highly employable, but they often attach great importance to the opportunity to do a type of work they care about and for which they have been trained. For that reason, no single measure can satisfactorily describe the doctoral S&E labor market. Some of the available labor market indicators, such as unemployment rates, IOF and in-field employment, satisfaction with field of study, employment in academia, postdocs, and salaries, are discussed below.

Aggregate measures of labor market conditions changed only slightly between 1999 and 2001 for recent (1–3 years after receipt of degree) S&E doctoral degree recipients. Unemployment rates for recent S&E doctoral degree recipients across all fields of study did not change significantly during that period (table 3-13). However, a smaller proportion of recent doctoral degree recipients reported working IOF (because jobs in their fields were not available) or involuntarily working part time; thus, the overall IOF rate decreased from 4.2 to 3.4 percent. However, these aggregate numbers mask numerous changes, both positive and negative, in many individual disciplines. In addition, IOF and unemployment rates in some fields moved in opposite directions.

Unemployment

Even for relatively good labor market conditions in the general economy, the 1.3 percent unemployment rate for recent S&E doctoral degree recipients as of April 2001 was very low; the April 2001 unemployment rate for all civilian workers was 4.4 percent and the rate for college graduates was 2.0 percent.[14] The highest unemployment rates were for recent doctoral degree recipients in civil engineering (3.5 percent), mechanical engineering (3.2 percent), and economics (2.2 percent).

[14]People are said to be unemployed if they were not employed during the week of April 15, 1999, and had either looked for work during the preceding 4 weeks or were laid off from a job.

Table 3-13
Labor market rate for recent doctorate recipients 1–3 years after receiving doctorate, by field: 1999 and 2001
(Percent)

Doctorate field	Unemployment rate 1999	Unemployment rate 2001	Involuntarily out-of-field rate 1999	Involuntarily out-of-field rate 2001
All S&E fields	1.2	1.3	4.2	3.4
Engineering	0.9	1.8	2.7	1.7
Chemical	1.7	1.6	1.8	2.0
Civil	1.5	3.5	0.0	3.6
Electrical	0.7	0.9	2.5	1.5
Mechanical	0.3	3.2	3.2	1.7
Life sciences	1.1	1.1	2.5	2.5
Agriculture	0.0	0.3	3.1	4.1
Biological sciences	1.3	1.0	2.5	2.4
Mathematics/computer sciences	0.8	0.3	4.1	2.4
Computer sciences	0.9	0.4	1.8	2.3
Mathematics	0.7	0.3	6.2	2.4
Physical sciences	0.4	1.3	6.6	5.0
Chemistry	0.5	0.8	2.4	3.2
Geosciences	1.2	1.9	9.4	3.0
Physics and astronomy	0.0	1.9	11.1	8.2
Social sciences	2.1	1.3	5.7	5.1
Economics	0.5	2.2	4.2	2.1
Political science	3.4	0.8	11.6	8.7
Psychology	1.0	1.4	3.5	3.8
Sociology and anthropology	1.6	1.2	11.9	6.3

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 1999 and 2001.

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Involuntarily Working Outside Field

Another 3.4 percent of recent S&E doctoral degree recipients in the labor force reported in 2001 that they could not find (if they were seeking) full-time employment that was "closely related" or "somewhat related" to their degrees—a small decrease from 4.2 percent in 1999.[15] Although this measure is more subjective than the unemployment rate, the IOF rate often proves to be a more sensitive indicator of labor market difficulties for a highly educated and employable population. However, it is best to use both IOF rate and unemployment rate as measures of two different forms of labor market distress.

The highest IOF rates were found for recent doctoral degree recipients in political science (8.7 percent), physics and astronomy (8.2 percent), and sociology and anthropology (6.3 percent). However, in every case, these rates represented a drop from even higher rates in 1999. The lowest IOF rates were found in electrical engineering (1.5 percent), mechanical engineering (1.7 percent), and economics (2.1 percent).

Tenure-Track Positions

Most S&E doctorate holders ultimately do not work in academia and this has been true in most S&E fields for several decades (see chapter 5). In 2001, among S&E Ph.D. holders who received their degree 4–6 years previously, 19.2 percent were in tenure-track or tenured positions at 4-year institutions of higher education (table 3-14). Across fields, rates of tenure program academic employment for individuals who had received their degree 4–6 years previously ranged from 4.3 percent in chemical engineering to 44.1 percent in sociology and anthropology. Among Ph.D. holders who received their degree 1–3 years previously, only 16.2 percent were in tenure programs; this rate reflects the increasing use of postdocs by recent doctoral degree recipients in many fields. Between 1999 and 2001, a paradoxical pattern occurred: the proportion of the most recent doctoral degree recipients in tenure-track positions increased (although it remained below 1993 levels), but members of the group who received their degree 4–6 years previously showed a continued decline.

Although S&E doctorate holders must consider academia just one possible sector of employment, the availability of tenure-track positions is an important aspect of the job market for individuals who seek academic careers. A decrease in the rate of tenure-track employment for individuals who received their degree 4–6 years previously, from 26.6 percent in 1993 to 19.2 percent in 2001, reflects the availability both of tenure-track job opportunities in academia and of alternative employment opportunities. For example, one of the largest declines in tenure-track employment occurred in computer sciences, from 51.5 percent in 1993 to 23.6 percent in 2001.

[15]Individuals counted as involuntarily out of field if they said they were working in jobs not related to their degree because no jobs in their field were available or if they were working part time because they could not find full-time work in their field.

Table 3-14
Doctorate recipients holding tenure and tenure-track appointments at 4-year institutions, by years since receipt of doctorate: 1993, 1999, and 2001
(Percent)

	1993		1999		2001	
Doctorate field	1–3 years	4–6 years	1–3 years	4–6 years	1–3 years	4–6 years
All S&E fields	18.4	26.6	13.7	22.2	16.2	19.2
Engineering	16.0	24.6	7.3	15.2	11.4	10.4
Chemical	8.1	14.0	2.4	6.5	5.8	4.3
Civil	24.7	27.1	20.3	33.6	18.8	21.7
Electrical	17.6	26.9	3.7	11.9	9.5	8.2
Mechanical	13.5	29.5	6.4	15.1	9.9	9.3
Life sciences	12.6	24.8	11.3	21.8	12.6	18.2
Agriculture	15.6	27.0	13.6	23.3	23.7	12.8
Biological sciences	12.1	24.8	10.9	22.0	11.3	18.3
Mathematics/computer sciences	39.7	54.1	20.8	36.7	22.5	26.6
Computer sciences	37.1	51.5	20.3	31.6	19.2	23.6
Mathematics	41.8	56.0	21.3	41.0	25.0	29.3
Physical sciences	9.7	18.2	8.1	15.2	10.2	14.9
Chemistry	7.7	16.3	9.4	14.2	10.2	11.5
Geosciences	12.7	26.2	14.3	24.0	17.7	25.4
Physics and astronomy	12.0	17.7	3.5	12.0	7.8	11.4
Social sciences	26.4	29.2	24.0	28.7	25.9	28.3
Economics	46.6	48.6	30.4	34.3	37.1	28.6
Political science	53.9	47.1	37.3	50.7	45.0	40.0
Psychology	12.7	15.5	14.9	16.0	14.8	19.3
Sociology and anthropology	37.9	46.9	33.4	43.4	41.3	44.1

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 1993, 1999, and 2001.

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Other measures of labor market distress in this field are low and computer science departments report difficulties recruiting faculty. The attractiveness of other areas of employment may also explain drops in tenure program rates for several engineering disciplines. However, it is less likely to explain smaller but steady drops in tenure program employment rates in fields that show other measures of distress, such as physics (with an IOF rate of 8.2 percent) and biological sciences (which has low unemployment and IOF rates, but shows other indications of labor market distress such as low salaries). Between 1993 and 2001, only psychology registered an increase in tenure program rates for individuals who received their doctorate 4–6 years previously, improving from 15.5 percent to 19.3 percent.

Relation of Occupation to Field of Degree

By strict definition of occupational titles, 16.9 percent of employed recent doctoral degree recipients worked in occupations outside S&E, often in administrative or management functions. However, when asked if their jobs related to their highest degree achieved, only 2.8 percent of recent doctoral degree recipients employed in non-S&E occupations reported that their jobs did not relate to their degree (table 3-15). By field, the percentages working in occupations not related to S&E ranged from 1.6 percent in computer sciences and mathematics to 3.6 percent in physical sciences. However, the 24.7 percent of recent doctoral degree recipients in physical sciences and the 22.8 percent of recent doctoral degree recipients in engineering working in other S&E fields may be more noteworthy. Figures show that 10.1 percent of recent doctoral degree recipients in physical sciences were working in life science occupations, and 15.8 percent of recent engineering doctoral degree recipients in computer sciences and mathematics (table 3-15).

Postdocs

The definition of postdocs differs among the academic disciplines, universities, and sectors that employ them, and these differences in usage probably affect self-reporting of postdoc status in the Survey of Recent Doctorate Recipients. Researchers often analyze data on postdoc appointments for recent doctoral degree recipients in relation to recent labor market issues. Although some of these individuals do want to receive more training in research, others may accept temporary (and usually lower-paying) postdoc positions because of a lack of permanent jobs in their field.

Science and Engineering Indicators – 1998 (NSB 1998) included an analysis of a one-time postdoc module from the 1995 Survey of Doctorate Recipients. This analysis showed a slow increase in the use of postdocs in many disciplines over time. (This rate was measured cross-sectionally by looking at the percentage of individuals in each graduation cohort who reported ever holding a postdoc position.) In addition, in physics and biological sciences (the fields with the most

Table 3-15
Scientists and engineers recently awarded doctorates, by degree field and relation to occupation: 2001
(Percent)

	Occupation relation to degree			
Doctorate field	Same field	Other S&E	Related non-S&E	Nonrelated non-S&E
Engineering	68.9	22.8	6.2	2.1
Life sciences	67.7	8.4	21.1	2.8
Mathematics/computer sciences	86.3	3.1	9.0	1.6
Social sciences	72.3	7.3	17.2	3.2
Physical sciences	64.5	24.7	7.2	3.6

NOTE: Percents may not sum to 100 because of rounding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 2001.

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use of postdocs), median time spent in postdocs extended well beyond the 1–2 years found in most other fields.

Compared with 1999, data from 2001 show a small decline in the percentage of recent S&E doctoral degree recipients entering postdocs; this rate fell from 31.5 percent of 1998 graduates to 29.5 percent of 2000 graduates (figure 3-24). Although many fields registered a small drop in the incidence of postdocs, the overall decline can mainly be attributed to a decrease in postdocs in the life sciences 1 year after degree from 56.4 percent in 1999 to 48.1 percent in 2001.

Reasons for Taking a Postdoc

In 2001, for all fields of degree, 11.5 percent of postdocs gave "other employment not available" as their primary reason for accepting a postdoc, compared with 32.1 percent of postdocs in 1999 (table 3-16 and NSB 2002). Most respondents gave reasons consistent with the defined training and apprenticeship functions of postdocs (e.g., 30 percent said that postdocs were generally expected for careers in their fields, 21 percent said they wanted to work with a particular person, 21 percent said they sought additional training in their fields, and 12 percent said they sought additional training outside their specialty). In 1999, a high proportion of postdocs in the biological sciences (38 percent) and physics (38 percent) had reported "other employment not available" as the primary reason for being in a postdoc, but in 2001, both fields had below average rates for this particular indicator of labor market distress.

Figure 3-24
Recent doctorate recipients in postdoc positions, by years since degree: 1999 and 2001

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 1999 and 2001.

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What Were 1999 Postdocs Doing in 2001?

Of individuals in postdocs in April 1999, 36.5 percent remained in a postdoc in April 2001. This represented a small reduction from the 38.0 percent of 1997 postdocs still in their positions in 1999 (NSB 2002). Only 12.3 percent had moved from a postdoc to a tenure-track position at a 4-year educational institution, down from 15.1 percent of 1997 postdocs in 1999; 20.2 percent had found other employment at an educational institution; and 31.0 percent had found some other form of employment (figure 3-25).

There is no available information on the career goals of individuals in postdoc positions. It is often assumed that a postdoc is valued most by academic departments at research universities. However, more postdocs in every field eventually accept employment with for-profit firms than obtain tenure-track positions, and many individuals accept tenure-track positions at schools that do not emphasize research.

Salaries for Recent S&E Ph.D. Recipients

In 2001, for all fields of degree, the median annual salary for recent S&E doctoral degree recipients reached $53,000, an increase of 8.2 percent from 1999. Across various S&E fields of degree, median annual salaries ranged from a low of $40,000 in the life sciences to a high of $75,000 in engineering (table 3-17). Among all doctoral degree recipients, individuals in the top 10 percent of salary distribution (90th

Table 3-16
Primary reason for taking current postdoc position, by degree field: 2001
(Percent)

Doctorate field	Additional training in field	Training outside field	Postdoc position generally expected in field	Association with particular person or place	Other employment not available	Other
All S&E fields	20.7	12.3	29.9	21.0	11.5	4.5
Biological sciences	21.0	12.3	34.3	18.7	9.4	4.2
Chemistry	15.5	16.9	26.9	18.2	19.0	3.6
Engineering	26.9	14.1	13.3	22.8	16.0	6.9
Geosciences	27.0	10.5	23.3	27.0	11.4	0.8
Physics	11.8	13.0	29.5	35.3	5.5	4.9
Psychology	27.2	11.6	35.5	15.9	7.9	2.9

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 2001.

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Table 3-17
Median annual salary of recent doctorate recipients 1–3 years after receiving degree, by percentile: 2001
(Dollars)

	Percentile				
Doctorate field	10th	25th	50th	75th	90th
All S&E fields	30,000	38,000	53,000	65,000	90,000
Engineering	48,000	60,000	75,000	87,000	100,000
Life sciences	28,300	32,000	40,000	60,000	75,000
Mathematics/computer sciences	37,500	45,000	68,800	90,000	108,000
Physical sciences	30,000	39,000	56,000	75,900	87,000
Social sciences	30,000	39,000	47,000	60,000	80,500

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 2001.

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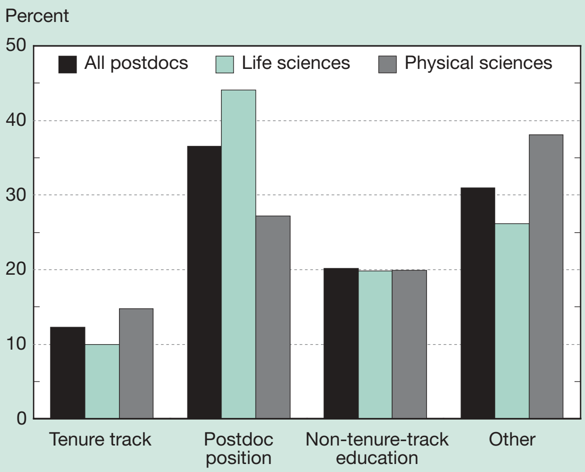
Figure 3-25
Status of 1999 S&E postdocs: 2001



SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, 2001.

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percentile) earned a median annual salary of $90,000. The 90th percentile salaries varied by field, from a low of $80,500 for individuals with degrees in the social sciences to a high of $108,000 for recent doctoral degree recipients in mathematics and computer sciences. At the 10th percentile, representing the lowest pay for each field, salaries ranged from $28,300 for recent doctoral degree recipients in the life sciences to $48,000 for individuals receiving degrees in engineering.

Table 3-18 shows changes in median annual salaries for recent bachelor's, master's, and doctoral degree recipients (1–5 years since receipt of degree) for the period from 1997 to 1999. For all S&E fields, median salaries for recent doctoral degree recipients rose 4.7 percent from 1997 to 1999. For bachelor's and master's degree graduates, median salaries rose 0.0 and 2.5 percent, respectively. Several individual disciplines reflected larger increases for doctoral degree recipients; this included double-digit increases in economics (10.3 percent), physics (10.4 percent), computer sciences (12.0 percent), and mathematics (12.5 percent). A decline in median salaries occurred in biology (–3.7 percent).

Salary is measured here as a labor market outcome for all graduates, regardless of occupation or section of employment. Hence some of the changes may reflect different

Table 3-18
Change from 1997 to 1999 in median salary for S&E graduates 1–5 years after receiving degree
(Percent)

Degree field	Bachelor's	Master's	Doctoral
All S&E fields	0.0	2.5	4.7
Engineering	7.5	10.0	7.5
Chemical	11.9	5.2	3.1
Civil	5.7	4.2	9.1
Electrical	9.3	9.1	7.1
Mechanical	8.8	2.0	3.3
Life sciences	0.0	6.3	–2.8
Agriculture	0.0	11.3	10.1
Biological sciences	0.0	6.3	–3.7
Mathematics/computer sciences	13.5	7.7	9.7
Computer sciences	9.8	9.1	12.0
Mathematics	3.5	12.5	12.5
Physical sciences	0.0	9.9	8.3
Chemistry	3.7	14.3	2.9
Geoscience	–3.6	–7.7	5.0
Physics	0.0	11.1	10.4
Social sciences	3.8	6.1	7.1
Economics	15.2	0.0	10.3
Political science	7.1	8.1	12.5
Psychology	4.2	1.3	1.2
Sociology/anthropology	4.2	3.3	12.6

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1997 and 1999.

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proportions going into academia or to even lower paying postdoc positions.

Age and Retirement

The age distribution and retirement patterns of the S&E labor force greatly affect its size, its productivity, and opportunities for new S&E workers. For many decades, rapid increases in new entries into the workforce led to a relatively young pool of workers, with only a small percentage near traditional retirement age. Now, the general picture is rapidly changing as individuals who earned S&E degrees in the late 1960s and early 1970s move into the latter part of their careers.

Some controversy exists about the possible effects of age distribution on scientific productivity. Increasing average age may mean increased experience and greater productivity among scientific workers. However, others argue that it could reduce opportunities for younger scientists to work independently. In many fields, scientific folklore as well as actual evidence indicates that the most creative research comes from younger people (Stephan and Levin 1992).

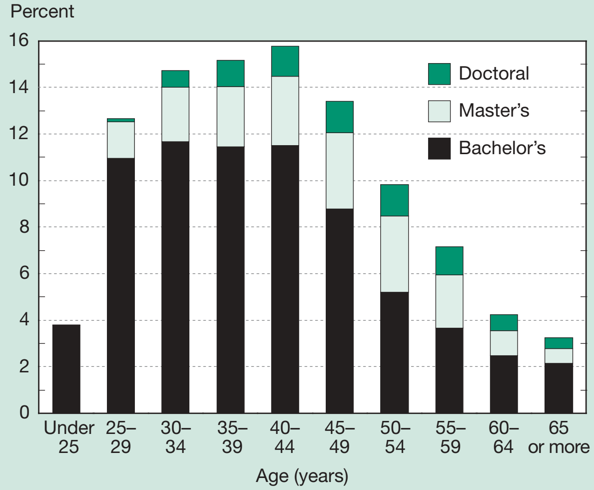
This section does not attempt to model and project future S&E labor market trends; however, some general conclusions can be made. Absent changes in degree production, retirement patterns, or immigration, the number of S&E-trained workers in the labor force will continue to grow for some time, but the growth rate may slow significantly as a dramatically greater proportion of the S&E labor force reaches traditional retirement age. As the growth rate slows, the average age of the S&E labor force will increase.

Implications for S&E Workforce

Net immigration, morbidity, mortality, and, most of all, historical S&E degree production patterns affect age distribution among scientists and engineers in the workforce. Appendix table 3-18 shows age distributions for S&E degree recipients in 1999, by degree level and broad field of degree. With the exception of new fields such as computer sciences (in which 56 percent of degree holders are younger than age 40), the greatest population density of individuals with S&E degrees occurs between the ages of 40 and 49. (Figure 3-26 shows the age distribution of the labor force with S&E degrees broken down by level of degree.) In general, the majority of individuals in the labor force with S&E degrees are in their most productive years (from their late 30s through their early 50s), with the largest group ages 40–44. More than half of workers with S&E degrees are age 40 or older, and the 40–44 age group is nearly four times as large as the 60–64 age group.

This general pattern also holds true for those individuals with S&E doctorate degrees. Ph.D. holders are somewhat older than individuals who have less advanced S&E degrees; this circumstance occurs because there are fewer doctorate holders in younger age categories, reflecting that time is needed to obtain this degree. The greatest population density of S&E Ph.D. holders occurs between the ages of 45 and 54. This can be most directly seen in figure 3-26, which

Figure 3-26
Age distribution of labor force with S&E highest degree, by degree level: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-18.

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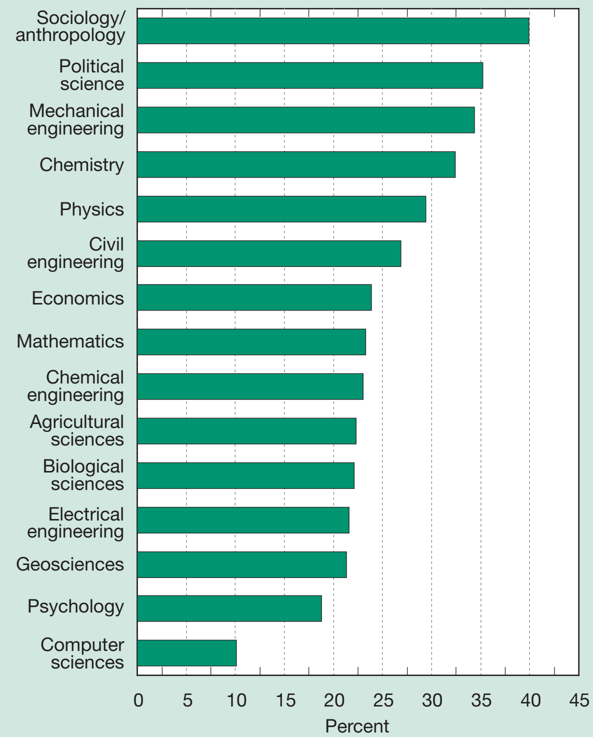
compares the age distribution of S&E degree holders in the labor force at each level of degree. Even if one takes into account the somewhat older retirement ages of doctorate holders, a much larger proportion of the doctorate holders are near traditional retirement ages than are individuals with either S&E bachelor's or master's degrees.

Across all degree levels and fields, 25.6 percent of the labor force with S&E degrees is older than age 50. The proportion ranges from 10.1 percent of individuals with their highest degree in computer sciences to 39.9 percent of individuals with their highest degree in sociology/anthropology (figure 3-27).

Taken as a whole, the age distribution of S&E-educated individuals suggests several likely important effects on the future S&E labor force:

- Barring large changes in degree production, retirement rates, or immigration, the number of trained scientists and engineers in the labor force will continue to increase, because the number of individuals currently receiving S&E degrees greatly exceeds the number of workers with S&E degrees nearing traditional retirement age.
- However, unless large increases in degree production occur, the average age of workers with S&E degrees will rise.
- Barring large reductions in retirement rates, the total number of retirements among workers with S&E degrees will dramatically increase over the next 20 years. This may prove particularly true for Ph.D. holders because of the steepness of their age profile. As retirements increase, the difference between the number of new degrees earned and the number of retirements will narrow (and ultimately disappear).

Figure 3-27
Employed S&E degree holders over age 50, by selected fields: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-19.

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Taken together, these factors suggest a slower-growing and older S&E labor force. Both trends would be accentuated if either new degree production were to drop or immigration to slow, both concerns raised by a recent report of the Committee on Education and Human Resources Task Force on National Workforce Policies for Science and Engineering of the National Science Board (NSB 2003).

S&E Workforce Retirement Patterns

The retirement behavior of individuals can differ in complex ways. Some individuals retire from one job and continue to work part time or even full time at another position, sometimes even for the same employer. Others leave the workforce without a retired designation from a formal pension plan. Table 3-19 summarizes three ways of looking at changes in workforce involvement for S&E degree holders: leaving full-time employment, leaving the workforce, and retiring from a particular job.

By age 62, 50 percent of both S&E bachelor's and master's degree recipients no longer work full time; however, S&E doctorate holders do not reach the 50 percent mark until age 66. Longevity also differs by degree level when measuring the number of individuals who leave the workforce entirely: half of S&E bachelor's and master's degree

Table 3-19
First age at which more than 50 percent of S&E degree holders are retired, by highest degree and employment status: 1999
(Years)

Highest degree	Not working full time	Not in labor force	Retired from any job
Bachelor's........	62	65	63
Master's...........	62	65	62
Doctoral...........	66	68	66

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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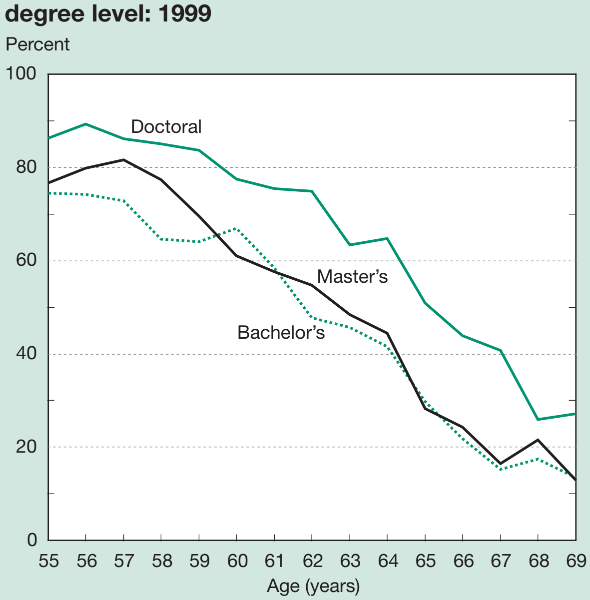
recipients had left the workforce entirely by age 65, but a similar proportion of Ph.D. holders did not do so until age 68. Formal retirement also occurs at somewhat higher ages for doctorate holders: more than 50 percent of bachelor's and master's degree recipients retired from employment by age 63, compared with age 66 for doctorate holders.

Figure 3-28 shows data on S&E degree holders leaving full-time employment at ages 55 through 69. For all degree levels, the portion of S&E degree holders who work full time declines fairly steadily by age, but after age 55, full-time employment for doctorate holders becomes significantly greater than for bachelor's and master's degree holders. At age 69, 27 percent of doctorate holders work full time compared with 13 percent of bachelor's or master's degree recipients.

Figure 3-28
Older S&E degree holders working full time, by degree level: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix table 3-20.

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The fact that a higher proportion of doctorate holders work in the academic sector or for the Federal Government may account for the slower retirement rate among doctorate holders. Table 3-20 shows rates at which doctorate holders left full-time employment, by sector of employment, between 1999 and 2001.[16] In 1999, within each age group, a smaller portion of doctorate holders employed at educational institutions (except at ages 66–70) or by the Federal Government (except at ages 71–73) left full-time employment compared with their counterparts employed in private noneducation sectors.

Although slower retirement rates (particularly in academia) for S&E doctorate holders are significant and of some policy interest, these slower rates do not mean that academic or other doctorate holders seldom retire. Indeed, figure 3-28 indicates retirement patterns similar to the ones for individuals holding bachelor's and master's degrees, with retirement simply delayed by 2 or 3 years. Even the 2-year transition rates for academia in table 3-20 show more than a third of individuals who were still working at ages 66 to 70 leaving full-time employment.

Although many S&E degree holders who formally retire from one job continue to work full or part time, this occurs most often among individuals younger than age 63 (table 3-21). The drop in workforce participation among the retired is more pronounced for part-time work; i.e., older retired S&E workers more often work full time than part time. Retired S&E doctorate holders follow this pattern, albeit with somewhat greater rates of postretirement employment than shown by bachelor's and master's degree recipients.

Global S&E Labor Force and the United States

"There is no national science just as there is no national multiplication table" *(Anton Chekhov, 1860–1904).*

Science is a global enterprise. The common laws of nature cross political boundaries, and the international movement of people and knowledge made science global long before "globalization" became a label for the increasing interconnections among the world's economies. The United States (and other countries as well) gains from new knowledge discovered abroad and from increases in foreign economic development.[17] U.S. industry also increasingly relies on R&D performed abroad. The nation's international economic competitiveness, however, depends upon the U.S. labor force's innovation and productivity.

[16]As a practical matter, it would be difficult to calculate many of the measures of retirement used previously in this chapter by sector of employment. However, a 2-year transition rate can be calculated using the NSF/SRS SESTAT data file matched longitudinally at the individual level.

[17]A discussion of this is contained in Regets 2001.

Table 3-20
Employed 1999 S&E doctorate holders leaving full-time employment by 2001, by employment sector: 1999
(Percent)

Age in 1999 (years)	All sectors	Education	Private	Government
51–55	6.3	3.1	10.2	5.1
56–60	10.3	7.4	14.2	9.7
61–65	25.6	22.7	32.3	19.9
66–70	33.6	37.9	29.7	15.0
71–73	36.9	34.9	38.6	41.1

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999 and 2001.

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Table 3-21
S&E-degreed individuals who have retired but continue to work, by highest degree: 1999
(Percent)

	Bachelor's		Master's		Doctoral	
Age (years)	Part time	Full time	Part time	Full time	Part time	Full time
50–55	12.1	52.9	12.5	66.8	16.9	57.0
56–62	14.4	27.8	21.3	36.9	17.0	38.7
63–70	14.5	8.3	17.1	11.9	19.3	11.6
71–75	8.1	8.4	11.9	3.3	15.2	6.1

NOTE: Retired refers to individuals who said they had ever retired from any job.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Other chapters provide indirect indicators on the global labor force. Production of new scientists and engineers through university degree programs is reported in chapter 2. Indicators of R&D performed by the global S&E labor force are provided in chapter 4 (R&D expenditures and alliances), chapter 5 (publication output and international collaborations), and chapter 6 (patenting activity).

Section Overview

Although the number of researchers employed in the United States has continued to grow faster than the growth of the general workforce, this is still a third less than the growth rate for researchers across all Organisation for Economic Co-operation and Development (OECD) countries. Foreign-born scientists in the United States are more than a quarter, and possibly more than a third of the S&E doctorate labor force, and are even more prevalent in many physical science, engineering, and computer fields. Along with the increases in graduate education for domestic and foreign students elsewhere in the world (as discussed in chapter 2), there has been an increase in efforts by national governments and private industry to recruit the best talent from wherever it comes. As a result, the United States is becoming less dominant as a destination for migrating scientists and engineers.

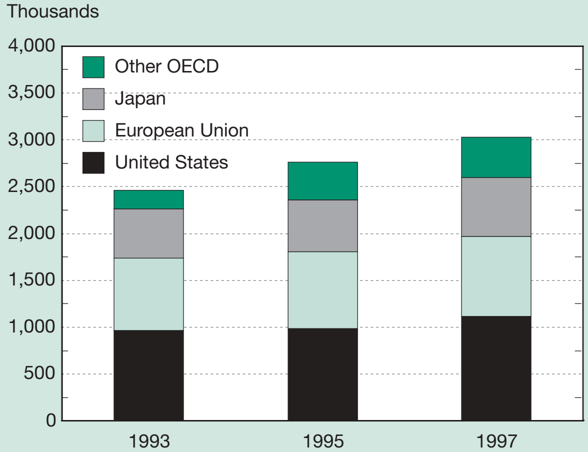
Counts of the Global S&E Labor Force

Few direct measures of the global S&E labor force exist. Reports on the number of researchers in OECD member countries do constitute one source of data. From 1993 to 1997, the number of researchers[18] reported in OECD countries increased by 23.0 percent (a 5.3 percent average annual rate of increase) from approximately 2.46 million to 3.03 million (figure 3-29). During this same period, comparable U.S. estimates increased 11.8 percent (a 3.7 percent average annual rate of increase) from approximately 965,000 to 1.11 million. Although researchers in the United States, Japan, and the European Union made up 85.7 percent of the OECD total in 1997, the greatest growth in number of researchers came from other OECD countries, with a 120 percent increase from 196,000 to 433,000. (These numbers represent OECD staff estimates of total researchers in all member countries; the rapid growth of "other OECD" may represent in part improvements in reporting.)

Of course, non-OECD countries also have scientists and engineers. Figure 3-30 shows an estimate (from disparate data sources) of the global distribution of tertiary education graduates (roughly equivalent in U.S. terms to individuals who have earned at least technical school or associate's degrees, and also including all degrees up to doctorate) during

[18]The OECD defines researchers as "professionals engaged in conception and creation of new knowledge, products, processes, methods, and systems."

Figure 3-29
Researchers in OECD countries, by country/region: 1993, 1995, and 1997



OECD Organisation for Economic Co-operation and Development

SOURCE: OECD, *Main Science and Engineering Indicators,* various years.

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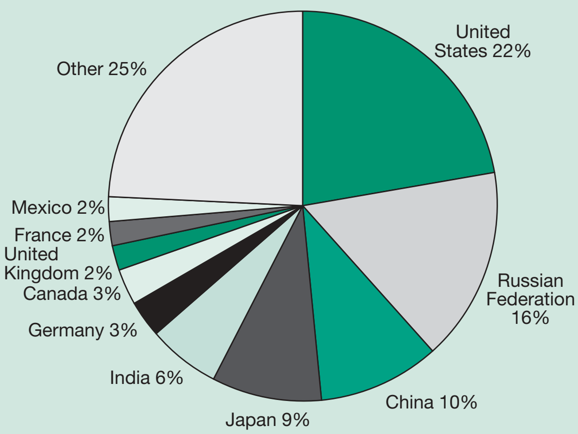
Figure 3-30
Global distribution of workers with tertiary education: 1990–98



NOTES: Estimates are based on various original data sources and reporting years and are not appropriate for direct comparison between countries but rather as an order-of-magnitude indicator of the global high-education workforce. No data are available from countries representing about 10 percent of global population. Tertiary education roughly corresponds to an associate's degree in the United States.

SOURCES: World Bank, *World Development Indicators,* annual series; National Bureau of Statistics of China: *1999 China Statistical Yearbook;* and Brazilian Institute for Geography and Statistics.

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the 1990s.[19] About one-fifth of the estimated 240 million tertiary graduates in the labor force were in the United States. However, of the 10 countries with the largest number of tertiary graduates, 3 do not belong to OECD: the Russian Federation, China, and India.

Migration to the United States

Migration of skilled S&E workers across borders is increasingly seen as a major determinant of the quality and flexibility of the labor force in most industrial countries. The knowledge of scientists and engineers can be transferred across national borders more easily than other skills. Additionally, cutting-edge research and technology inevitably create unique sets of skills and knowledge that can be transferred through the physical movement of people. The United States has benefited, and continues to benefit, from this international flow of knowledge and personnel. However, competition for skilled labor continues to increase. An NSB taskforce noted "[g]lobal competition for S&E talent is intensifying, such that the United States may not be able to rely on the international S&E labor market to fill unmet skill needs" (NSB 2003). (See sidebar, "High-Skill Migration to Japan")

In April 1999, SESTAT figures indicated that at least 27 percent of S&E doctorate holders in the United States were foreign born (table 3-22), along with 20 percent of those with S&E master's degrees and 10 percent of S&E bachelor's degree holders. Technical reasons make it difficult to estimate the extent of participation of foreign-born scientists and engineers in the U.S. S&E workforce in the 1990s.[20] Minimum estimates based on a sample drawn originally from the 1990 Census have turned out to be considerably low, reflecting the difficulty in measuring the dimensions of high-skilled entry into the U.S. during the 1990s.

An indication of the scope of the undercounting of foreign-born scientists and engineers comes from a comparison of SESTAT occupational data with approximately comparable data from the 2000 Census. Using the 5 percent Public Use Microdata Sample (PUMS), it is possible to compare the proportion of foreign-born individuals among

[19]The primary source is World Bank data on size and percentage of the labor force with a tertiary education, supplemented with data from various national data agencies. However, these data come from different years for different countries and result from estimates taken from very different national data collection systems. Consequently, these data are not suitable for making direct comparisons between countries. In addition, data were not available from countries representing about 10 percent of the global population.

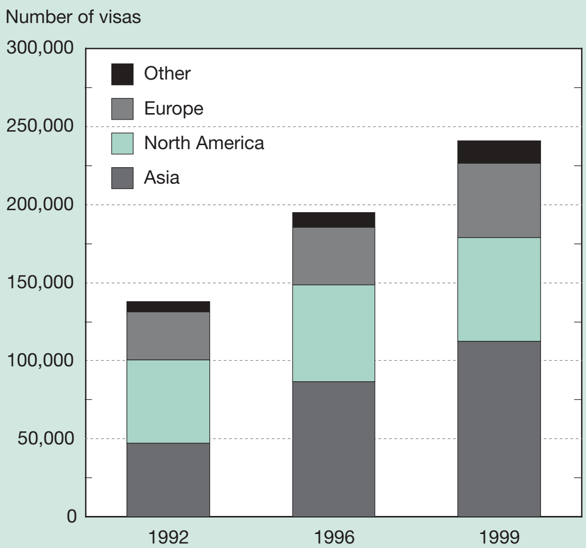
[20]Because the NSF's demographic data collection system cannot refresh its sample of individuals with S&E degrees from foreign institutions (as opposed to foreign-born individuals with a new U.S. degree, who are sampled) more than once per decade, counts of foreign-born scientists and engineers are likely to be underestimates. The 1999 estimate includes foreign-degreed scientists and engineers only to the extent that they were in the United States in April 1990. In 1993, 34.1 percent of foreign-born S&E doctorate recipients and 49.1 percent of foreign-born S&E bachelor's recipients had acquired their degrees from foreign schools (NSF/SRS 1999c).

High-Skill Migration to Japan

Recent political debate and legislative change in the United States, Germany, Canada, and many other developed countries have focused on visa programs for temporary high-skilled workers. A 1989 revision of Japanese immigration laws made it easier for high-skilled workers to enter Japan with temporary visas, which allow employment and residence for an indefinite period (even though the same visa classes also apply to work visits that may last for only a few months).

Scott Fuess of the University of Nebraska (Lincoln) and the Institute for the Study of Labor (Bonn) analyzed 12 Japanese temporary visa occupation categories associated with high-skilled workers. In 1999, 240,936 workers entered Japan in high-skilled visa categories, a 75 percent increase compared with 1992 (figure 3-31). For comparison purposes, this equals 40 percent of the number of Japanese university graduates entering the labor force each year and nearly doubles the number entering the United States in roughly similar categories (H-1b, L-1, TN, O-1, O-2) (Fuess 2001).

Figure 3-31
High-skilled worker visas in Japan, by country of origin: 1992, 1996, and 1999



SOURCE: S. Fuess, Jr., *Highly Skilled Workers and Japan: Is There International Mobility?* Workshop paper presented at Institute for the Study of Labor, Bonn, Germany, 2001).

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those with S&E occupations other than postsecondary teacher[21] (table 3-23). According to the 1999 SESTAT, 15.0 percent of college graduates in S&E occupations are foreign born, compared with the 22.4 percent recorded by the 2000 Census. A particularly noteworthy difference appears in the proportion of foreign-born individuals among those with doctorates; this proportion increases from 28.7 percent in SESTAT to 37.6 percent in the 2000 Census.

Among college-educated workers with occupations in the life sciences, physical sciences, and mathematical and computer sciences, estimates from the 2000 Census indicate that approximately one-fourth of individuals, across all degree levels, were foreign born (table 3-24). At the doctorate level, 51.3 percent of individuals in engineering occupations, and just under 45 percent in the life sciences, physical sciences, and mathematical and computer sciences, were foreign born. The lowest percentage of foreign-born individuals is found in social science occupations, where just over 10 percent of workers are foreign born (regardless of degree level).

The large increases shown by 2000 Census data may in part reflect recent arrivals in the United States, because 42.5 percent of all college-educated foreign-born individuals in S&E occupations reported arriving in the United States after 1990. Among foreign-born doctorate holders in S&E occupations, 62.4 percent reported arriving in the United States after 1990. The NSF/SRS estimates in table 3-23 include these post-1990 arrivals only if their degrees are from a U.S. institution.[22]

Origins of S&E Immigrants

Immigrant scientists and engineers come from a broad range of countries. Figure 3-32 shows countries contributing more than 30,000 individuals to the 1.5 million S&E degree holders in the United States, by S&E doctorate and by highest degree achieved in S&E. Although no one source country dominates, among individuals whose highest degree achieved is in S&E, 14 percent came from India, 10 percent came from China, and 5 percent each came from the following countries: Germany, the Philippines, the United Kingdom, Taiwan, and Canada. By region, 57 percent came from Asia (including the Western Asia sections of the Middle East), 24 percent came from Europe, 13 percent came from Central and South America, 6 percent came from Canada and Oceania, and 4 percent came from Africa.

Fiscal year 2001 data from the Bureau of Citizenship and Immigration Services (BCIS)[23] counts of permanent visas issued to immigrants in S&E show a large increase in permanent visas for S&E occupations to 33,917, dominated by growth in engineering and mathematical/computer sciences (figure 3-33). This reflects both a general increase in permanent visas issued due to efforts to eliminate backlogs (1,064,318 total permanent visas were issued in 2001), and the first opportunity for many workers on H-1b temporary work visas to adjust to permanent status. Adjustments from temporary work visas (which includes other cases besides H-1b) rose from 44,598 in FY 2000 to 85,227 in FY 2001. It

[21]The 2000 Census occupation codes do not allow categorization of postsecondary teachers by field.

[22]It is also likely that noncitizens with U.S. degrees would not be part of NSF/SRS estimates if they reentered the United States during the 1990s after an extended period abroad.

[23]The Bureau of Citizenship and Immigration Services is one of the successor agencies to the Immigration and Naturalization Service, which was eliminated in early 2003.

Table 3-22
Foreign-born S&E-trained U.S. scientists and engineers, by field and level of highest degree: 1999
(Percent)

Field	All degree levels	Bachelor's	Master's	Doctoral
All S&E fields	12.2	9.9	19.9	27.0
Engineering	19.8	14.6	31.1	44.6
Chemical	20.2	14.9	34.9	40.8
Civil	21.2	16.1	35.5	51.5
Electrical	23.3	18.3	33.5	47.2
Mechanical	16.5	11.6	33.4	49.2
Other	17.0	11.3	24.2	40.9
Life sciences	11.7	8.8	13.7	26.1
Agriculture	7.9	5.4	14.9	22.7
Biological sciences	13.3	10.4	14.0	27.0
Mathematics/computer sciences	17.1	12.8	26.4	35.4
Computer sciences	21.1	15.2	34.3	46.4
Mathematics	12.5	10.2	15.4	31.1
Physical sciences	15.8	11.2	17.2	29.3
Chemistry	19.3	14.9	24.8	29.7
Geosciences	7.9	5.3	9.8	19.1
Physics/astronomy	18.2	9.8	18.9	32.5
Other	10.4	9.8	8.4	36.1
Social sciences	7.5	6.7	10.0	12.9
Economics	13.5	11.2	25.8	25.9
Political science	7.2	6.3	11.9	15.2
Psychology	6.2	6.1	6.4	7.6
Sociology/anthropology	6.1	5.3	12.4	12.7
Other	7.8	6.4	10.8	21.6

SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999.

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Table 3-23
Comparison between NSF and Census estimates of foreign-born individuals in S&E occupations, by level of education: 1999 and 2000
(Percent)

Level of education	1999 NSF/SRS SESTAT	2000 Census 5-Percent PUMS
All college educated	15.0	22.4
Bachelor's	11.3	16.5
Master's	19.4	29.0
Professional degree	10.0	35.8
Doctorate	28.7	37.6

NSF/SRS National Science Foundation, Division of Science Resources Statistics
SESTAT Scientists and Engineers Statistical Data System
PUMS Public Use Microdata Sample

NOTE: Includes all S&E occupations other than postsecondary teachers because field of instruction was not included in occupation coding for the 2000 Census.

SOURCES: NSF/SRS, SESTAT, 1999; and U.S. Bureau of the Census, PUMS, 2000.

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is worth noting that FY 2001 ended on September 30, 2001, and thus was mostly unaffected by any changes in administrative practices or individual behaviors resulting from the events of September 11, 2001. (See sidebar, "Has September 11th Affected the U.S. Scientific Labor Force?")

Temporary Work Visas

In recent years, policy discussion has focused on the use of various forms of temporary work visas by foreign-born scientists. Many newspaper and magazine stories have been written about the H-1b visa program, which provides visas for up to 6 years for individuals to work in occupations requiring at least a bachelor's degree (or to work as fashion models). Although a common misperception exists that only information technology (IT) workers may use these visas, a wide variety of skilled workers actually use H-1b visas.

Exact occupational information on H-1b visas issued is not available. Some occupational data on H-1b admissions, which count individuals who re-enter the United States multiple times, does exist. This information can provide an approximate guide to the occupational distribution of individuals on H-1b visas. Individuals working in computer-related positions accounted for more than half (57.8 percent) of H-1b admissions, and architecture and engineering constituted another 12.2 percent. Another 9.0 percent labeled scientific and technical occupations and 8.7 percent in categories such as education and medicine also may include many individuals with S&E backgrounds (table 3-26).

An important change to the H-1b visa program took effect on October 1, 2003: the annual ceiling on admis-

Table 3-24
Foreign-born individuals in S&E occupations, by level of education and occupation group: 2000
(Estimated percent)

Level of education	All S&E occupations	Engineers	Life scientists	Mathematical/ computer scientists	Physical scientists	Social scientists
All college educated	22.4	20.8	25.6	24.7	26.8	11.3
Bachelor's	16.5	15.2	8.3	19.0	14.6	10.4
Master's	29.0	29.4	18.5	37.0	24.7	10.7
Professional degree	35.8	32.7	58.8	31.5	46.5	12.7
Doctorate	37.6	51.3	44.9	44.6	44.7	12.8

NOTE: Includes all S&E occupations other than postsecondary teachers because field of instruction was not included in occupation coding for the 2000 Census.

SOURCE: U.S. Bureau of the Census, Public Use Microdata Sample (PUMS) 2000 (5-percent sample).

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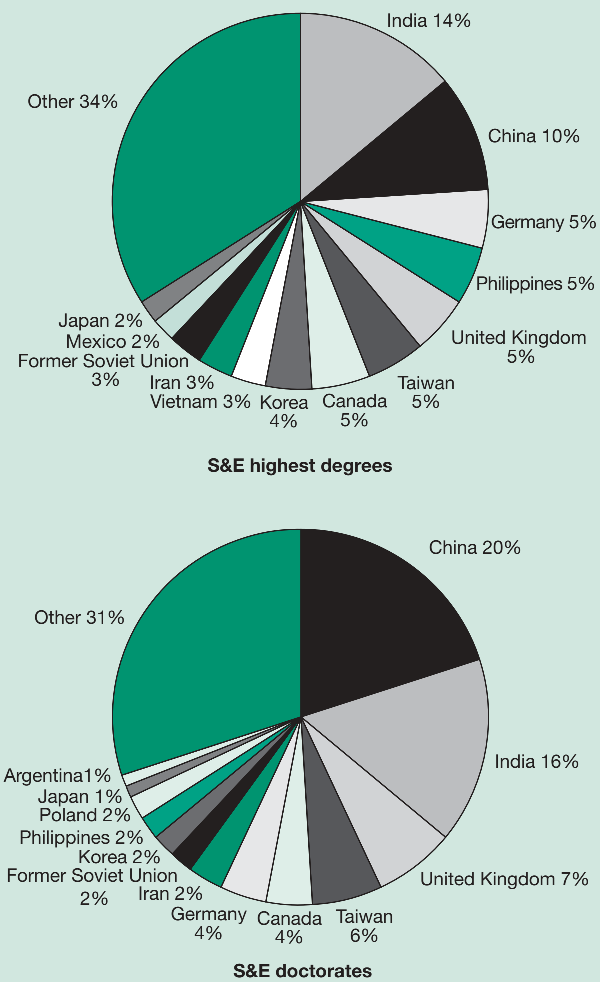
Figure 3-32
Foreign-born U.S. residents with S&E highest degree, by country of birth: 1999



SOURCE: National Science Foundation, Division of Science Resources Statistics, Scientists and Engineers Statistical Data System (SESTAT), 1999. See appendix tables 3-21 and 3-22.

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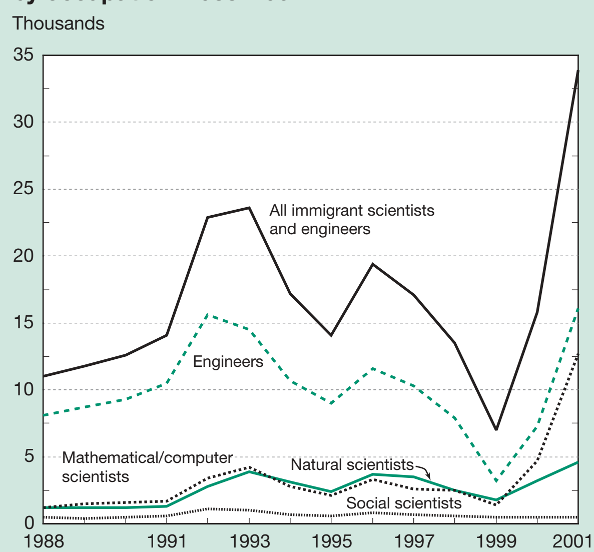
Figure 3-33
Permanent visas to individuals in S&E occupations, by occupation: 1988–2001



SOURCE: U.S. Department of Homeland Security, Bureau of Citizenship and Immigration Services, administrative data. See appendix table 3-23.

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sions fell from 195,000 to 65,000 due to the expiration of legislation that had allowed the additional visas. Although universities and academic research institutions are exempt from this ceiling, this change is likely to constrain the use of foreign scientists and engineers by private industry for any R&D located in the United States.

Scientists and engineers may also receive temporary work visas through intracompany transfer visas (L-1 visas), high-skilled worker visas under the North American Free Trade Agreement (TN-1 visas, a program currently primarily for Canadians, will grant full access for Mexican professionals by 2004), work visas for individuals with outstanding

Has September 11th Affected the U.S. Scientific Labor Force?

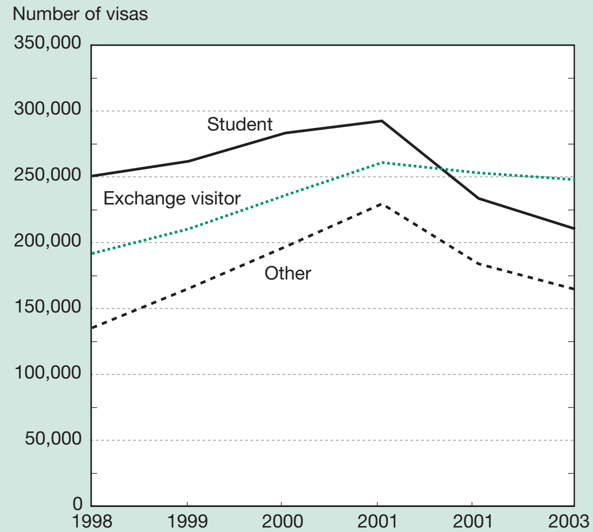
The ability and willingness of people to cross national borders crucially affects the science and technology enterprise in the United States. Foreign students help to fill graduate classrooms and laboratories. Visiting scientists facilitate the exchange of knowledge in ways that the telephone and the Internet cannot. Most importantly, foreign-born scientists constitute more than one-fourth of the science and engineering doctorate holders doing research in both academia and in industry. For this reason, a great deal of concerned speculation has focused on the effects of the tragic events of September 11, 2001, on the mobility of scientists to the United States. For most areas of concern, no data exists on even short-term effects. However, data is available on temporary visas issued by the State Department for fiscal year 2002, which began in October 2001, and for most of FY 2003 (table 3-25 and figure 3-34).

Between FY 2001 and FY 2002, the number of F-1 student visas issued dropped by 20.1 percent. A smaller drop (3.0 percent) occurred for exchange visitors (J-1), a category often used for visiting faculty and postdocs. For all categories of temporary work visas combined, the number dropped 19.8 percent. Part of the decline in temporary work visas may be explained by decreased demand due to economic conditions.

Although full FY2003 figures were not available at time of publication, further declines in high-skill related visas issued appear to have occurred. Counting just the period through September 14th of each fiscal year, student visas issued in 2003 were 27 percent below their 2001 peak. For the same 50-week period, the number of exchange visitor visas continued to decline slightly in 2003, to 4 percent below the 2001 level, and the number of other high-skill related visas issued declined by 26 percent.*

These declines occurred through two mechanisms—a decrease in the number of workers and students applying for visas and an increase in the proportion of visa applications rejected by the U.S. Department of State (table 3-25). Since FY 2001, the refusal rate for F-1 student visas has risen from 27.6 percent to 35.2 percent; at the same time, applications for F-1 visas fell by 18.5 percent. High-skilled related work visas followed a similar pattern, with applications down by 19.4 percent and the refusal rate increasing from 9.6 to 17.8 percent. However, exchange visitor visas followed a different pattern: applications rose from 2001 to 2003 but the total number of visas issued still declined due to a doubling of the refusal rate from 7.8 percent to 15.9 percent (table 3-25)

Figure 3-34
Student, exchange visitor, and other high-skill-related temporary visas issued: FY 1998–2003



NOTES: Student visa is F-1, exchange visitor visa is J-1, and other high-skill-related visas include L-1, H-1b, H-3, O-1, 0-2, and TN. FY 2003 data are through September 14 and thus exclude the last 2 weeks of the fiscal year.

SOURCE: U.S. Department of State, Immigrant Visa Control and Reporting Division. See appendix table 3-24.

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Table 3-25
Visa applications by major high-skilled categories: FY 2001–2003

	Student (F-1)		Exchange visitor (J-1)		Other high-skill related visas	
Year	Applications	Percent refused	Applications	Percent refused	Applications	Percent refused
2001	399,988	27.6	279,524	7.8	248,421	9.6
2002	346,419	33.3	278,598	10.5	203,551	11.9
2003	325,844	35.2	295,624	15.9	200,233	17.8

NOTES: Data for each fiscal year are through September 14 and exclude last 2 weeks of reporting. Other high-skill related visas include L-1, H-1b, H-3, 0-1, O-2, and TN visas.

SOURCE: U.S. Department of State, Immigrant Visa Control and Reporting Division, administrative data.

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*An annual survey of U.S. schools by the Institute of International Education (2004) showed a slowdown in the growth of international students on U.S. campuses in academic year 2002/2003, but enrollment in S&E fields still grew by 2.7 percent. These numbers reflect changes in the existing stock of foreign students as well as new entrants in the first year after the decline in visa issuances. It is possible that the total number of foreign S&E students will grow for a short time even if there is a further decline in new entrants.

Table 3-26
H-1b visa admissions, by occupation: FY 2001

Occupation	Number	Percent
All occupations	331,206	100.0
Computer related	191,397	57.8
Architecture, engineering, and surveying	40,388	12.2
Education	17,431	5.3
Medicine	11,334	3.4
Life sciences	6,492	2.0
Social sciences	6,145	1.9
Mathematical/physical sciences	5,772	1.7
Other professional/technical	5,662	1.7
Other (non-S&E related)	46,585	14.1

NOTE: Total admissions includes each entry to the United States and thus is much greater than the number of visas issued.

SOURCE: U.S. Department of Homeland Security, Bureau of Citizenship and Immigration Services, administrative data.

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abilities (O-1 visas), and several smaller programs. In addition, there are temporary visas used by researchers who may also be students (F-1 and J-1 visas) or postdocs, and by visiting scientists (mostly J-1 visas but often H-1b visas or other categories). Counts of visas issued for each of these categories are shown in table 3-27. The annual quota of H-1b visas is controlled through issuance of visas to workers rather than through applications from companies.

Stay Rates for U.S. Doctoral Degree Recipients With Temporary Visas

How many foreign students who receive S&E doctorates from U.S. schools remain in the United States? According to a report by Michael Finn (2003) of the Oak Ridge Institute for Science and Education, 56 percent of 1996 U.S. S&E doctoral degree recipients with temporary visas remained in the United States in 2001. The number of foreign students staying after obtaining their doctorates implies that approximately 3,500 foreign students remain from each annual cohort of new S&E doctorates in all fields. Stay rates differ by field of degree, ranging from only 26 percent in economics to 70 percent in computer and electrical engineering (table 3-28).

Table 3-27
Temporary visas issued in categories likely to include scientists and engineers: FY 2002

Visa type	Category	Number of visas
Work		
H-1b	Specialty occupations requiring bachelor's equivalent	118,351
L-1	Intracompany transfers	57,721
O-1	People of extraordinary ability	6,026
O-2	Workers assisting O-1	1,972
Student/exchange		
F-1	Students	234,322
J-1	Exchange visitors	253,841

SOURCE: U.S. Department of State, Immigrant Visa Control and Reporting Division, administrative data. See appendix table 3-24.

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Table 3-28
Temporary residents living in United States who received U.S. doctorates in 1996, by degree field: 1997–2001
(Percent)

Degree field	1997	1998	1999	2000	2001
All S&E fields	59	57	56	56	56
Agricultural sciences	40	38	37	38	38
Computer sciences	66	65	64	64	63
Computer/electrical engineering	73	72	70	70	70
Economics	27	27	27	27	26
Life sciences	65	63	61	63	63
Mathematics	59	59	57	57	57
Other engineering	62	59	59	58	58
Other social sciences	37	35	36	35	34
Physical sciences	66	65	63	63	64

SOURCE: M. Finn, Oak Ridge Institute for Science and Education, 2003.

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Within each discipline, the stay rate remained mostly stable for the 1996 graduation cohort between 1997 and 2001. Quite possibly, however, some of this stability came from individuals in this cohort who re-entered the United States and thus replaced others in the same graduation cohort who left.

Conclusion

The U.S. S&E labor market continues to grow, both in absolute numbers and as a percentage of the total labor market. Although the most dramatic growth has occurred in the IT sector, other areas of S&E employment also have recorded strong growth over the past two decades.

In general, labor market conditions for individuals with S&E degrees improved during the 1990s. (These conditions have always been better than the conditions for college graduates as a whole.) However, engineering and computer science occupations have been unusually affected by the recent recession, causing the unemployment rate for individuals in S&E occupations to reach a 20-year high of 3.9 percent in 2002. Labor market conditions for new doctoral degree recipients have also been good, according to most conventional measures; for example, the vast majority of S&E doctorate holders are employed and doing work relevant to their training. However, these gains have come in the nonacademic sectors; that is, in nearly all fields, a smaller percentage of recent doctoral degree recipients obtained tenure-track positions.

The globalization of the S&E labor force continues to increase as the location of S&E employment becomes more internationally diverse and S&E workers become more internationally mobile. These trends reinforce each other as R&D spending and business investment crosses national borders in search of available talent, as talented people cross borders in search of interesting and lucrative work, and as employers recruit and move employees internationally. Although these trends appear most strongly in the high-profile international competition for IT workers, they affect every science and technology area.

The rate of growth of the S&E labor force may decline rapidly over the next decade due to the aging of individuals with S&E educations, as the number of individuals with S&E degrees reaching traditional retirement ages is expected to triple. If this slowdown does occur, the rapid growth in R&D employment and spending that the United States has experienced since World War II may not be sustainable.

The growth rate of the S&E labor force would also be significantly reduced if the United States becomes less successful in the increasing international competition for immigrant and temporary nonimmigrant scientists and engineers. Many countries are actively reducing barriers to high-skilled immigrants entering their labor markets at the same time that entry into the United States is becoming somewhat more difficult.

Slowing of the S&E labor force growth would be a fundamental change for the U.S. economy, possibly affecting both technological change and economic growth. Some researchers have raised concerns that other factors may even accentuate the trend (NSB 2003). Any sustained drop in S&E degree production would produce not only a slowing of labor force growth, but also a long-term decline in the S&E labor force.

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