pared with S&E Ph.D.-holders employed by for-profit companies and in all sectors combined.

Although slower retirement for S&E Ph.D.-holders (particularly in academia) is significant and of some policy interest, it is important to recognize that this does not mean that academic or other Ph.D.-holders seldom retire. Indeed, figure 3-18 indicates that their retirement patterns are similar to those for bachelor's and master's degree-recipients; retirement for Ph.D.-holders is just delayed two or three years. Even the two-year transition rates for academia in text table 3-21 show more than 40 percent of those ages 66–70 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 those younger than age 63. (See text table 3-22.) The drop in workforce participation among the "retired" is more pronounced for part-time work; i.e., older retired S&E workers are more likely to be working full time than part time. Retired Ph.D. scientists and engineers follow this pattern, albeit with somewhat greater rates of postretirement employment than shown by bachelor's and master's degree-recipients. See sidebar, "Are Information Technology Careers Difficult for Older Workers?"

Projected Demand for S&E Workers

During the 2000–2010 period, employment in S&E occupations is expected to increase about three times faster than the rate for all occupations. (See text table 3-23.) Although the economy as a whole is expected to provide approximately 15 percent more jobs over this decade, employment opportunities for S&E jobs are expected to increase by about 47 percent (about 2.2 million jobs).

Approximately 86 percent of the increase in S&E jobs will likely occur in computer-related occupations. Overall employment in these occupations across all industries is expected to increase by about 82 percent over the 2000–2010 decade, adding almost 1.9 million new jobs. 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, 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.

Job opportunities in life science occupations are projected to grow by almost 18 percent (33,000 new jobs) over the 2000–2010 period; at 27 percent (10,000 new jobs), medical science occupations are expected to experience the largest growth. Employment in physical science occupations is expected to increase by about 18 percent (from 239,000 to 283,000 jobs); slightly less than one-half of these projected job gains are for environmental scientists (21,000 new jobs).

Social science occupations are expected to experience above-average growth (20 percent) over the decade largely due to the employment increases anticipated for market and survey researchers (27 percent, or 30,000 new jobs). Demand for psychologists is also projected to be favorable (18 percent, or 33,000 new jobs).

Text table 3-21.
Employed, 1997 S&E doctorate holders leaving full-time employment by 1999: by sector of employment in 1997
(Percentages)

Age in 1997 (years)	All sectors	Four-year schools	For-profit company	Government
51–55	5.6	4.1	6.4	3.9
56–60	9.5	5.1	17.3	5.8
61–65	21.6	18.3	33.5	19.8
66–70	45.1	43.2	38.4	64.7
71–73	32.6	29.7	—	—

— = Insufficient sample size for estimate

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

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Text table 3-22.
S&E-degreed individuals who have "retired" but continue to work: 1999
(Percentages of those retired)

	Highest degree					
	Bachelor's		Master's		Ph.D.	
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 means those who said they had ever retired from any job.

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

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The Global S&E Workforce and the United States

"There is no national science just as there is no national multiplication table." —Anton Chekov (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

Are Information Technology Careers Difficult for Older Workers?

Compared with other science and technology careers, many assert that information technology (IT) is more hostile toward older workers. It has been claimed that cultural factors associated with a younger average age in IT occupations, on-the-job time pressures often associated with short project cycles, and rapid skill obsolescence associated with rapid changes in technology all adversely affect conditions for older IT workers. Recent information on this issue follows:

- The unemployment rate in 1999 for workers older than age 40 who had computer science degrees (any level) was 1.7 percent, greater that the 0.9 percent unemployment rate for those age 40 and younger with computer science degrees. However, this is a low rate of unemployment and is lower than the 1.9 percent unemployment rate found for non-IT science and engineering (S&E) graduates over age 40.
- Looking more broadly at all S&E graduates in IT occupations, IT workers over age 40 had an unemployment rate of 1.8 percent compared with 0.6 for younger IT workers and 1.8 percent for other S&E-trained workers over age 40.
- Looking at all college-educated IT workers (including non-S&E) between 1988 and 1993, those over age 40 left computer occupations at a much lower rate (14.1 percent) than did IT workers under age 25 (24.7 percent), and they left at about the same rate as IT workers ages 25–40 (14.3 percent).
- College-educated IT workers over age 40 faced greater risk of layoff during the 1988–1993 period: about 10.4 percent of 1988 computer occupation holders over age 40 were laid off during this five-year period compared with a 9.0 percent layoff rate for all college-educated computer workers and a 4.4 percent layoff rate for other college graduates.

Examining various data sources on IT workers and taking public testimony, a recent National Academy of Sciences Panel on the Information Technology Workforce concluded in part that:

> [T]he data are insufficient to establish either the presence or absence of age discrimination.…With all that said, the committee believes that the nation cannot afford to underutilize valuable human resources…and the differential experiences of older IT workers indicates some likelihood that this qualified segment of the workforce is not being fully utilized.

Text table 3-23.
Total S&E jobs: 2000 and projected 2010
(Numbers in thousands of jobs)

Occupation	2000	2010	Change
Total, 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
Computer and mathematical occupations	2,408	4,308	1,900
Computer specialists	2,318	4,213	1,895
Mathematical science occupations	89	95	5
Physical scientists	239	283	44
Social scientists	410	492	82
Engineers	1,465	1,603	138

See appendix table 3-53. *Science & Engineering Indicators – 2002*

and from increases in foreign economic development. 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.

Other chapters in *Science and Engineering Indicators 2002* provide indirect indicators on the global labor force: production of new scientists and engineers through university degree programs is reported in chapter 2, and indicators of work performed by the global S&E labor force are provided in the chapter's discussion of international patenting activity and in chapter 5's data on R&D expenditures.

Few direct measures of the global S&E labor force exist. One source of data is the reports on the number of researchers in Organisation for Economic Co-operation and Development (OECD) member countries. From 1993 to 1997, the number of reported researchers in OECD countries increased by 23.0 percent (a 5.3 percent average annual rate) from approximately 2.46 million to 3.03 million. (See figure 3-19.) During this same period, comparable U.S. estimates increased 11.8 percent (a 3.7 percent average annual rate) 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 researchers came from other OECD countries, increasing 120 percent, or from 196,000 to 433,000.[21]

It is not, however, only OECD countries that have scientists and engineers. Figure 3-20 shows an estimate from disparate data sources during the 1990s of the global distribution of tertiary education graduates—roughly equivalent in U.S. terms to those who have earned at least technical school or associate degrees but also including all degrees up to Ph.D.[22] 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 are non-OECD: Russia, China, and India.

Migration of Scientists and Engineers 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, any cutting-edge research or technology inevitably creates 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 greatly from this international flow of knowledge and personnel.

In April 1999, 27 percent of doctorate-holders in S&E in the United States were foreign born. (See text table 3-24.)[23] The lowest percentage of foreign-born doctorate-holders was in psychology (7.6 percent), and the highest percentage was in civil engineering (51.5 percent). Almost one-fifth (19.9 percent) of those with master's degrees in S&E were foreign born. Even at the bachelor's degree level, 9.9 percent of those with S&E degrees were foreign born; the largest percentages of degrees were in chemistry (14.9 percent), computer sciences (15.2 percent), and engineering (14.6 percent).

Origins of S&E Immigrants

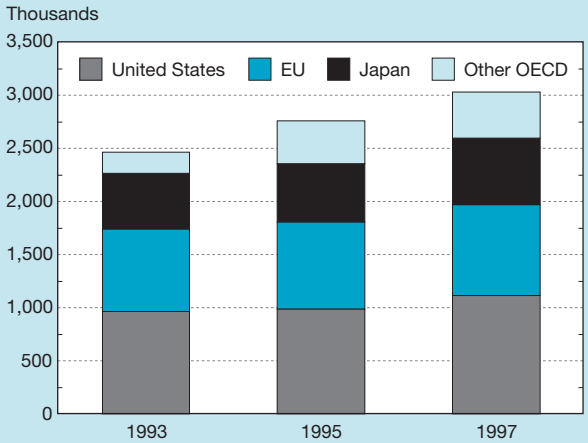
Immigrant scientists and engineers come from various countries. Countries contributing more than 30,000 natives to the 1.5 million S&E degree-holders in the United States are shown in figure 3-21 by S&E doctorate and by high degree achieved in S&E. Although no one source country dominates, of those with S&E high degrees, 8 percent came from India, 7 percent came from China, 4 percent came from the Philippines, and 4 percent came from Germany (including

[21] Although 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.

[22] The primary data source used is World Bank data on labor 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 are the result of estimates from very different national data collection systems. Hence, 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.

[23] Because NSF's demographic data collection system is unable to refresh its sample of those 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. Foreign-degreed scientists and engineers are included in the 1999 estimate only to the extent that they were in the United States in April 1990. In 1993, 34.1 percent of foreign-born doctorate recipients in S&E and 49.1 percent of foreign-born bachelor's recipients in S&E had acquired their degrees from foreign schools.

Figure 3-19.
Total researchers in OECD countries



EU = European Union

OECD = Organisation for Economic Co-operation and Development

SOURCE: Organisation for Economic Co-operation and Development Main S&E Indicators.

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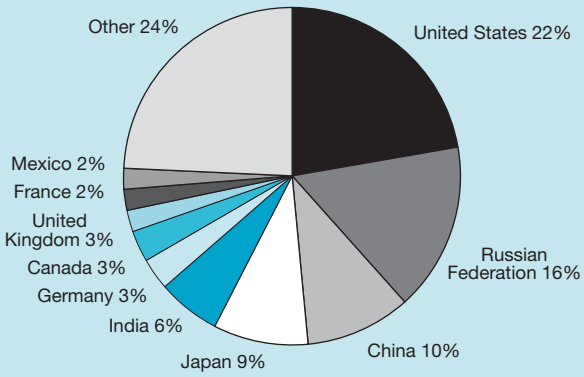
Figure 3-20.
Global distribution of workers with tertiary education: 1990–98



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

SOURCES: World Bank World Development Indicators, China National Bureau of Statistics: 1999 China Statistical Yearbook, Insituto Brasilerio de Geografia e Estatistica.

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Text table 3-24.
Foreign-born S&E-trained U.S. scientists and engineers, by field of highest degree and highest degree level: 1999
(Percentages)

Field of highest degree	Total labor force	Bachelor's	Master's	Doctorate
All S&E	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
Computer and mathematical sciences	17.1	12.8	26.4	35.4
Computer sciences	21.1	15.2	34.3	46.4
Mathematical sciences	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 and 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 and 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 (NSF/SRS), Scientists and Engineers Statistical Data System (SESTAT), 1999

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those born in the former East Germany). 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.

The 1999 data (which are the most recent) on Immigration and Naturalization Service (INS) counts of permanent visas issued to immigrants in S&E show a small decrease in permanent visas for each S&E occupation. (See figure 3-22.) However, the total number of immigrants employed in S&E is somewhat higher than that before 1992—a year in which various legislative and administrative changes took effect. See sidebars, "High-Skill Migration to Japan" and "Foreign Scientists and Engineers on Temporary Work Visas."

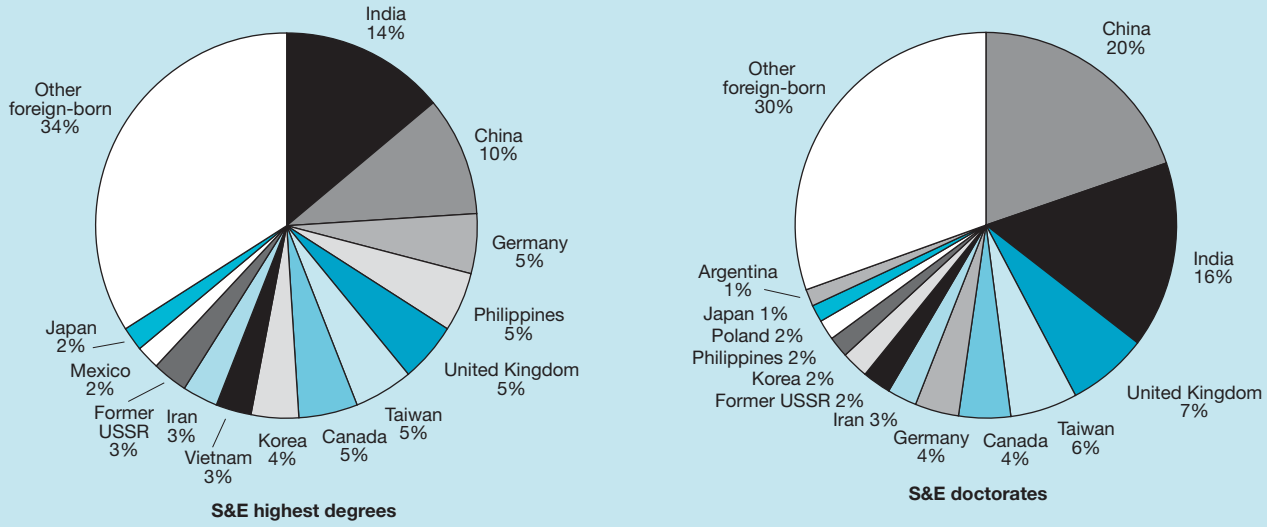
The quantity of permanent visas issued in recent years has been greatly affected by both immigration legislation and administrative changes at INS. The 1990 Immigration Act led to increases in the number of employment-based visas available, beginning in 1992. The 1992 Chinese Student Protection Act enabled Chinese nationals in the United States on student or other temporary visas to acquire permanent resident visas. These changes have allowed more scientists and engineers to obtain permanent visas.[24]

Stay Rates for U. S. Ph.D. Recipients With Temporary Visas

How many foreign students who receive S&E Ph.D.s from U.S. schools remain in the United States? According to a report by Michael Finn (2001) of the Oak Ridge Institute for Science and Education, 51 percent of 1994–95 U.S. S&E doctorate recipients with temporary visas were still in the United States in 1999. The actual numbers of foreign students staying after obtaining their Ph.D.s imply that approximately 3,500 foreign students remained from each annual cohort of new S&E doctorates in all fields. By field, the percentages ranged from 26 percent in economics to 63 percent in computer sciences. (See text table 3-27.) Within each discipline, the stay rate was mostly stable for the 1994–95 graduation cohort between 1996 and 1999. Quite possibly, however, some of this stability came from individuals in this cohort who reentered the United States and thus replaced others who left. Finn also finds an increase

[24]In addition, the easier availability of occupation-based permanent visas affects our measurements: many scientists enter on family-based visas, for which reporting of occupation is optional. If more of these individuals were using occupational visas, the number of foreign-born individuals identified as having S&E occupations would be greater.

Figure 3-21.
Foreign-born with S&E highest degrees by place of birth: 1999



SOURCE: NSF/SRS 1999 Scientists and Engineers Statistical Data System file.

See appendix table 3-51 and 3-52.

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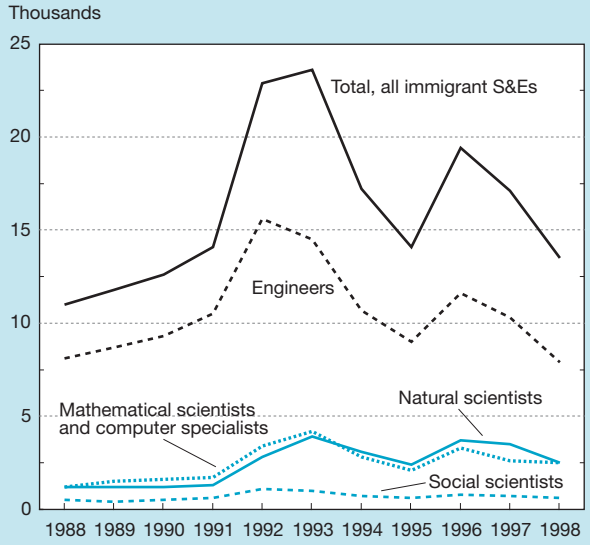
Figure 3-22.
Immigration and naturalization service counts of permanent visas to S&E occupations: 1988–98



SOURCE: Immigration and Naturalization Service Administration Records.

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over time in the shorter one-to-two-year stay rate of temporary visa S&E doctorate recipients from 40 percent in 1989 to 63 percent in 1999. This increase in the short-term stay rate may reflect increased opportunities for postdocs in the U.S. as well as an increased ability of industry to hire high-skilled workers on temporary visas.

Conclusion and Summary

The U.S. S&E labor market continues to grow both in absolute numbers and in its percentage of the total labor market. Even without the dramatic growth of IT jobs, other areas of S&E employment have had strong growth over the past two decades.

In general, labor market conditions for those with S&E degrees, although always better than for college graduates as a whole, have improved during the 1990s. Labor market conditions for new Ph.D. recipients have also been good by most conventional measures—S&E doctorate-holders are employed and doing work relevant to their training—but the gains have come in the nonacademic sectors (i.e., in most fields, a smaller percentage of recent Ph.D. recipients are obtaining tenure-track positions).

The age structure of the U.S. S&E labor force is likely to produce several major changes in the S&E labor market over the next decade. The number of individuals with S&E degrees reaching traditional retirement ages is expected to triple. Despite this, if S&E degree production remains at current rates, the number of S&E-trained individuals in the labor market will likely continue to grow for some time, albeit at a lower rate, as the number of new graduates continues to exceed the number of retirees.

The globalization of the S&E labor force is expanding in two ways: location of S&E employment is becoming more internationally diverse, and S&E workers are becoming more internationally mobile. Although both trends are highlighted by the high-profile international competition for IT workers, every field of science and technology has been affected.