Chapter 3
Science and Engineering Workforce

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HIGHLIGHTS

LABOR MARKET EXPERIENCE

- **In 1993, recent college graduates encountered a job market that was more favorable than for the general labor force.** The 1993 unemployment rates for students who graduated in either 1991 or 1992 were 4.4 percent for bachelor's degree recipients and 3.5 percent for master's degree recipients. By comparison, the unemployment rate for the U.S. labor force, as a whole, in 1993 was much higher at 6.8 percent.

- **With few exceptions, salaries are higher for science and engineering (S&E) graduates than for non-S&E graduates at each degree level.** This is true even in the relatively lower paid life and social sciences fields. S&E doctorate holders earn 23.0 percent more than S&E master's/professional degree holders and 42.9 percent more than S&E bachelor's degree holders. Median salaries for S&E doctorate holders rise steadily with years since completion of the doctoral degree.

- **Most people with degrees in science and engineering work at jobs at least somewhat related to their degrees.** A majority (52.8 percent) of those with bachelor's degrees in engineering work as engineers; just 19.4 percent work in an unrelated non-S&E occupation. The social sciences have the lowest proportion of bachelor's graduates working in the same field as their degree (1.5 percent); however, many of these graduates work in what they describe as closely related fields; only 34.9 percent work in an unrelated non-S&E occupation.

SELECTED CHARACTERISTICS OF POPULATION

- **A majority of S&E doctorate holders work in the same field as their degree—ranging from 57.4 percent in the life and physical sciences to 74.3 percent in mathematics/computer sciences.** Also, large numbers of S&E doctorate holders work in other fields of science or in various non-S&E occupations. Notably, in the physical sciences, 15.8 percent of Ph.D. holders work in some other S&E field. The percent of doctorate holders working in a non-S&E occupation unrelated to the field of their highest degree ranges from 8.3 percent in mathematics/computer sciences to 19.8 percent in the life sciences.

- **In 1993, recent S&E doctorate recipients in sociology, geoscience, physics/astronomy, and mechanical engineering were more likely to be working outside their field or part-time (in either case, not by choice) than recent S&E doctoral recipients in other fields.** Except for mechanical engineering, these fields also have relatively high unemployment rates.

- **The proportion of women among nonacademic scientists and engineers increased from 12.6 percent in 1980 to 22.2 percent in 1990.** This increase occurred across all occupational fields. Over the same period, the proportion of blacks among nonacademic scientists and engineers increased from 3.2 to 4.4 percent; the percentage of Hispanics increased from 2.2 to 3.1 percent; and Asians increased from 4.2 to 6.0 percent of all those with S&E occupations.

INDUSTRIAL JOB PATTERNS

- **While the overall number of S&E jobs in industry increased by approximately 2.5 percent between 1990 and 1993, employment in most S&E fields declined.** Growth in the number of computer- and mathematics-related jobs was the principal factor contributing to the increase in total industrial S&E employment in the early 1990s.

FEDERAL EMPLOYMENT

- **The Federal S&E workforce increased by 6 percent between 1989 and 1993, from 185,623 to 196,908.** During this time, the number of female scientists and engineers employed in the Federal Government increased by 27 percent, from 29,328 to 37,341. In contrast, the number of male scientists and engineers grew by only 2 percent over the same period. The number of Federal scientists and engineers who are members of ethnic/racial minority groups also rose between 1989 and 1993, from 26,052 to 30,810. The number of Asians increased by 20.9 percent during this period, while the number of black scientists and engineers increased by 15.1 percent. The number of Native Americans in the Federal S&E workforce grew by 34.4 percent and the number of Hispanics grew by 19.9 percent during this time. These data do not reflect the recent cuts in Federal employment.

IMMIGRANT SCIENTISTS AND ENGINEERS

- **Foreign-born scientists and engineers represented 23.0 percent of S&E doctorate holders under age 76 in the United States in 1993.** Although a majority received their degrees from U.S. institutions, 34.1 percent received their doctorates from foreign schools.

Introduction

In the early 1990s, the Nation's science and engineering (S&E) workforce faced challenges new and different from those it experienced in the 1980s. The recession, defense-related spending cutbacks, reduced research and development (R&D) budgets, and industry downsizing have all taken their toll on S&E employment. Manufacturing S&E employment declined for the first time in more than a decade, and unemployment rates rose. Despite these trends, scientists and engineers have fared better than almost any other kind of worker. Moreover, the tight labor market has not precluded some S&E-trained individuals from finding meaningful, challenging work opportunities outside traditional S&E occupations.

Scientists and engineers continue to play vital roles in the technological performance of U.S. industry in such areas as product or process innovation, quality control, and productivity enhancement. In addition, they conduct basic research to advance the understanding of nature, perform R&D in a variety of areas such as health and national defense, train the Nation's future scientists and engineers, and improve the scientific and technological literacy of the Nation.

This chapter examines labor market conditions for recent bachelor's, master's, and doctoral S&E degree recipients, past and projected growth of S&E jobs in the industrial sector, which forms the core of demand for S&E occupations, and S&E job growth in the Federal Government. This chapter presents information on general characteristics and the sex and racial/ethnic composition of the S&E workforce. Finally, it provides data on foreign-born scientists and engineers.

Labor Market Experience: Recent Science and Engineering Bachelor's and Master's Graduates

Recent S&E bachelor's and master's degree recipients form a key component of the Nation's S&E workforce; they account for almost half of the annual inflow to the S&E labor market (SRS 1990, p. 40). The career choices of recent graduates and their entry into the labor market affect the balance between the supply of and demand for scientists and engineers in the United States. Analysis of the workforce status and other characteristics of recent S&E graduates can yield valuable labor market information.[1]

This section provides several labor market measures that offer useful insights into the overall supply and demand conditions for recent S&E graduates in the United States. Among these measures are median annual salaries, unemployment rates, and in-field employment rates.

[1]Data for this section are taken from the 1993 National Survey of Recent College Graduates. This survey collected information on the 1993 workforce/other status of 1991 and 1992 bachelor's and master's degree recipients in S&E fields. Surveys of recent S&E graduates have been conducted biennially for the National Science Foundation since 1978. For information on standard errors associated with survey data, see SRS (forthcoming [a]).

Market Conditions

Upon graduation, new S&E bachelor's and master's degree recipients must decide whether to enter the job market or to continue their education. In 1993, approximately three-quarters of the recent S&E degree recipients were employed on a full-time basis. (See figure 3-1.) About one-fifth of recent S&E bachelor's and master's graduates were enrolled in graduate school on a full-time basis. Students who majored in the physical and related sciences were more likely to go to graduate school than students with degrees in computer and mathematical sciences or engineering. (See appendix table 3-1.)

Unemployment Rates

The unemployment rate, which measures the percentage of those in the workforce who are not employed but are seeking work, is a standard measure of labor market conditions. In 1993, recent college graduates encountered a job market that was less favorable than the market in the late 1980s. The 1993 unemployment rates for students who graduated in either 1991 or 1992 were 4.4 percent for baccalaureate degree recipients and 3.5 percent for master's degree recipients (SRS, forthcoming [a]). For students who graduated in 1986 or 1987, unemployment rates in 1988 were 2.4 percent for baccalaureate recipients and 1.7 percent for master's degree recipients (SRS, 1990). The unemployment rate for the U.S. labor force as a whole in 1993 was 6.8 percent, compared with 5.5 percent in 1988 (BLS, 1995).

In-Field Employment

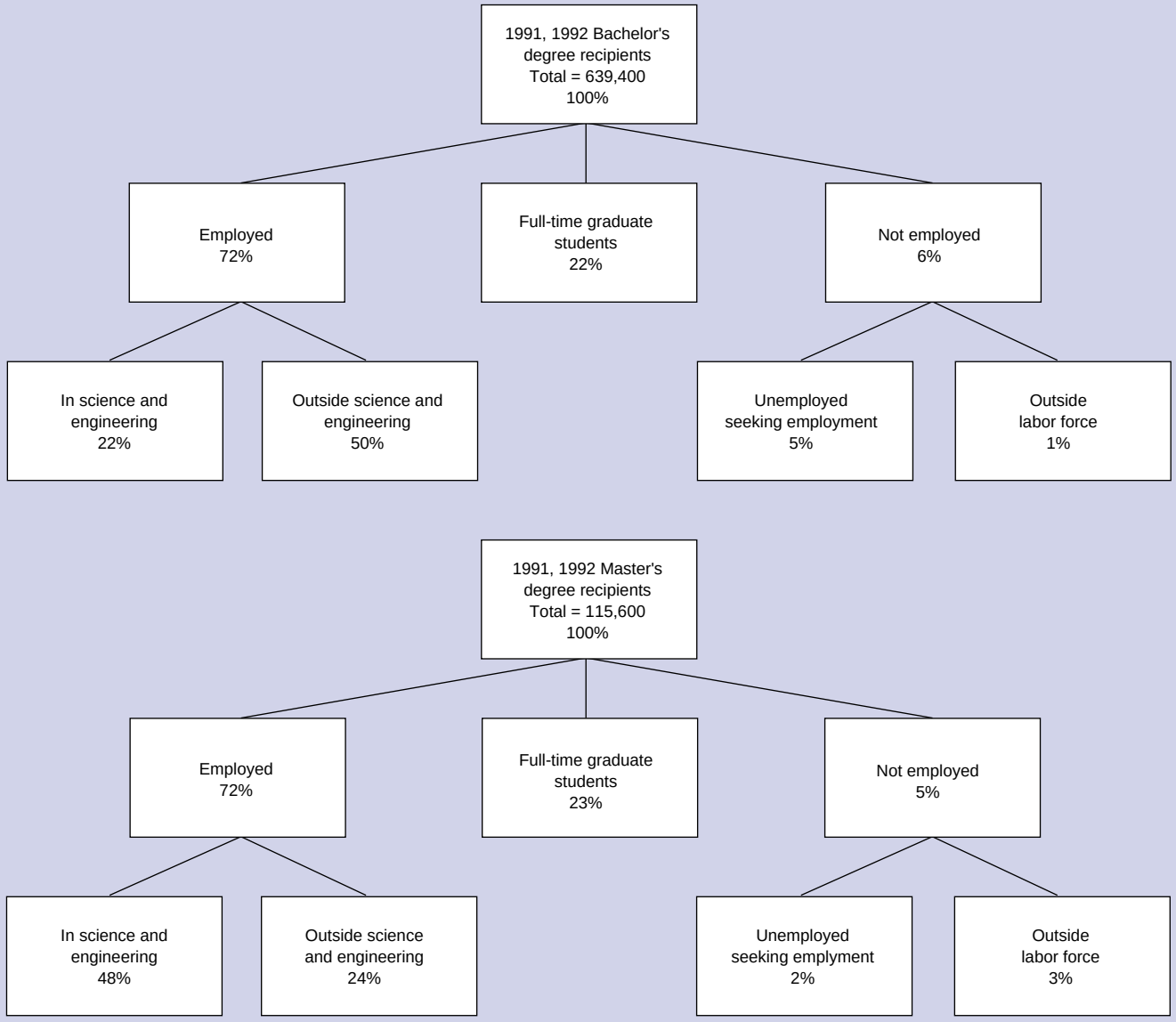
Many recent S&E graduates, especially master's degree recipients, find jobs directly related to their degree fields. Approximately half of all master's degree recipients were employed in their degree field in 1993, compared with one-fifth of all bachelor's recipients (SRS, forthcoming [a]). For both master's and bachelor's degree recipients, students who had received degrees in either engineering or computer science were more likely to be working in their field of study, while students who had majored in the social and related sciences were less likely to have jobs directly related to their degrees.

Median Annual Salaries

Median annual salaries[2] of recent S&E graduates provide an excellent indicator of the relative demand for new workers in various S&E fields. In 1993, the median annual salary of employed recent bachelor's degree recipients was $24,000; for master's degree recipients it was $38,100. (See appendix table 3-1.) The highest salaries commanded at the baccalaureate level were among students who had majored in engineering. For example, students with degrees in chemical engineering

[2]This refers to the median annual salary of full-time employed civilians rounded to the nearest $100.

Figure 3-1.
Transition of recent science and engineering degree recipients: 1993



See appendix table 3-1.

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reported salaries of $40,000. The highest salaries at the master's level were also in engineering. Graduates with degrees in electrical, electronics, computer, communications, and chemical engineering reported median annual salaries of $44,000.

Sectors of Employment

The private, for-profit sector is, by far, the largest employer of recent bachelor's and master's degree recipients. In 1993, 59 percent of bachelor's degree recipients and 47 percent of master's degree recipients were employed in a private, for-profit company. (See text table 3-1.) The academic sector was the next largest sector of employment for recent S&E graduates. Master's degree recipients were more likely to be employed in 4-year colleges and universities (25 percent) than were bachelor's degree recipients (13 percent). Master's degree recipients were also more likely to be employed in the Federal sector (9 percent) than were bachelor's degree recipients (5 percent). Sectors employing smaller numbers of recent S&E graduates include educational institutions other than 4-year colleges and universities, nonprofit organizations, and state or local government agencies.

Text table 3-1.
Percent of employed 1991 and 1992 science and engineering bachelor's and master's degree recipients, by sector of employment and field of degree: 1993

Degree and field	Total employed	Sector of employment: Private for-profit company	Self-employed	4-year college and university	Other educational institution	Nonprofit organization	Federal Government	State or local Government
	In thousands	Percent						
Bachelor's degree recipients								
Sciences and engineering	540.4	59	2	13	7	7	5	6
All sciences	432.8	56	2	14	9	9	4	7
All engineering	107.6	72	2	11	1	2	8	5
Master's degree recipients								
Sciences and engineering	103.1	47	2	25	7	5	9	5
All sciences	65.3	38	3	29	11	6	7	6
All engineering	37.8	63	1	18	1	2	13	3

NOTE: Details may not add to totals because of rounding. Percents were calculated on unrounded data.

SOURCE: Science Resources Studies Division, National Science Foundation, *National Survey of Recent College Graduates*, 1993, unpublished tabulations.

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Labor Market Experience: Recent Science and Engineering Doctorate Recipients

This section focuses on the employment status of recent S&E doctoral degree recipients. There has been increasing concern about labor market opportunities for new Ph.D. scientists and the possible consequences on the health of scientific research in the United States.[3] Several recent developments have contributed to these concerns, including demographic changes (which have slowed the growth in undergraduate enrollment), reductions in defense and research funding, growth in the importance of foreign doctoral programs, the 1990–91 economic recession, and rates of Ph.D. production that approach or exceed the high levels at the end of the Vietnam draft.

Unemployment of or involuntary movement out of the science fields by large numbers of new Ph.D. scientists and engineers could have a number of adverse effects on the health of scientific research in the United States. If labor market difficulties are real but temporary, promising students may be discouraged from pursuing degrees in S&E fields. Eventually, this would reduce the ability of industry, academia, and government to perform R&D. If labor market difficulties are long-term, restructuring will need to take place within graduate education and Federal research support to maintain quality research and some degree of fairness for new doctorate recipients. In either case, when a significant portion of high-level human capital goes unused, society loses potential opportunities for new knowledge and economic advancement, and individuals feel frustrated in their careers.

For the above reasons, it is important to examine the extent of labor market problems for new doctorate recipients. Information on the labor activities of recent doctorate recipients is available primarily from the National Science Foundation's (NSF) Survey of Doctorate Recipients (SDR). The SDR is a survey of approximately 60,000 individuals under age 76 who have received Ph.D.s in science, engineering, or the humanities from U.S. educational institutions. Unfortunately, changes in questionnaire design in 1993 and in survey collection techniques in 1991 make it difficult to compare the most current Ph.D. labor market indicators with previous years.

Unemployment Rates

In April 1993, the overall unemployment rate for recent S&E doctorate recipients[4] stood at 1.7 percent. (See text table 3-2.) The rates varied widely by field—from 0.7 percent for agricultural scientists and 0.8 percent for chemical engineers to 4.6 percent for sociologists and 4.0 percent for physicists and geoscientists. According to the U.S. Bureau of Labor Statistics, in 1993, the unemployment rate for the entire U.S. labor force was 6.8 percent.[5] As another point of comparison, the unemployment rate for recent doctorate recipients in the humanities was 3.3 percent—nearly double the average for all recent S&E doctorate recipients, but not as high as in many fields.

[3]For a more detailed discussion, see Committee on Science, Engineering, and Public Policy, 1995.

[4]Recent doctoral degree recipients are defined here as individuals who completed their Ph.D.s within the past 5 years.

[5]The Bureau of Labor Statistics monthly unemployment rate is calculated from the Current Population Survey. Comparing rates from two different surveys always is problematic.

Text table 3-2.
Labor market indicators for recent Ph.D.s (1988–92 graduates in April 1993)

	Involuntarily out-of-field rate	Unemployment rate	Nontenure-trk./ adjunct positions	Postdoc positions
	Percent			
All S&E	3.6	1.7	6.5	15.5
Computer/mathematical sciences	3.4	1.2	9.7	3.5
Computer science	1.4	1.1	3.2	3.0
Mathematical science	4.9	1.2	15.0	3.8
Engineering	3.4	1.5	4.3	6.1
Chemical engineering	2.6	0.8	2.1	3.1
Electrical/electronic engineering	2.8	1.6	3.7	3.4
Mechanical engineering	6.5	1.1	5.0	8.7
Life sciences	2.3	1.2	8.0	31.6
Agricultural science	2.2	0.7	7.2	23.3
Biological science	2.1	1.0	8.0	33.6
Physical sciences	5.0	2.6	5.0	24.6
Chemistry	3.5	1.6	4.1	21.5
Geosciences	7.7	4.0	6.1	17.8
Physics/astronomy	6.5	4.0	6.5	33.4
Social sciences	4.2	2.0	6.8	2.5
Economics	2.7	3.2	5.8	2.1
Political science	4.4	2.8	5.5	0.7
Psychology	2.5	1.0	6.3	3.3
Sociology/anthropology	9.6	4.6	9.5	2.5
Humanities	14.2	3.3	10.7	0.5

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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Involuntarily Outside of Doctoral Field

Many concerns being expressed about the labor market prospects of recent S&E doctorate recipients have less to do with graduates' ability to find a job than with their ability to get full-time jobs that use their training.

For the purposes of this chapter, individuals are considered involuntarily outside of their Ph.D. field if they state in an NSF survey that they are either working part-time solely because a full-time job was not available or that one reason they are working outside of their Ph.D. field is because a job in their field was not available.[6]

The involuntary out-of-field (IOF) rate for all recent S&E doctorate recipients is 3.6 percent. (See text table 3-2.) In 1993, IOF rates for recent S&E doctorate recipients ranged from 1.4 percent for computer science to 9.6 percent for sociology. In addition to sociology, particularly high IOF rates are found for geosciences (7.7 percent), physics/astronomy (6.5 percent), and mechanical engineering (6.5 percent). Recent doctorate recipients in the humanities have an IOF rate of 14.2 percent.

Although it is problematic to compare these rates with those for previous years,[7] the highest IOF rates are in fields (sociology, geosciences, and physics) that anecdotally have had the most problems in recent years.[8] In many ways, the IOF rate may be a better indicator of labor market conditions for doctorate holders than the unemployment rate. For example, the IOF rate is highest in the humanities (14.2 percent), where professional associations have long acknowledged labor market difficulties for their new doctorate recipients; recent humanities doctorate recipients have only a moderate unemployment rate of 3.3 percent.

Adjunct/Non-Tenure-Track Positions

Non-tenure-track positions, often with 1- or 2-year contracts, are one type of temporary job that a recent Ph.D. might take while hoping to obtain a permanent academic position. The highest rate of non-tenure-track jobs or

[6]All of NSF's SESTAT (Scientists and Engineers Statistics) surveys (which include the SDR) ask respondents to check off all that apply from sets of reasons why they are working part-time or why they are working outside the field of their highest degree. If a more restrictive definition were used—classifying full-time employment as involuntarily out of field only if "job in highest degree not available" was the only reason cited—the involuntarily out of field rate for all recent S&E doctorate holders would fall from 3.6 to 2.2 percent in 1993.

[7]This 1993 measure can not be compared with previous years, as it is based upon redesigned SDR survey questions on the relationship between individuals' jobs and Ph.D. training. In addition, major improvements in survey response rates in the 1991 and 1993 SDRs due to computer-assisted telephone interviews make it problematic to compare over time any attribute, such as working outside the Ph.D. field, that may be strongly correlated with a willingness to return a questionnaire.

[8]For sociology, the end of the Cold War was less of a factor in the labor market, but anecdotes refer to stagnant undergraduate enrollments and the development of competing ethnic studies programs in the humanities.

adjunct positions occurs in the mathematical sciences, but there has been a tradition in mathematics of postdoctoral lectureships that serve some of the same career functions that research postdocs serve in other disciplines. (See text table 3-2.) Across all S&E fields, the non-tenure-track/adjunct rate was 6.5 percent. These figures do not include individuals who were counted as involuntarily out-of-field or who have postdoctoral positions. Thus, a part-time adjunct professor who is not part-time by choice will not be included here.

Although the non-tenure-track/adjunct rate is included here as a labor market indicator, care should be taken in interpreting this as a measure of labor market distress. Many academic adjunct positions, particularly in the sciences, are highly desirable.

Postdoctoral Appointments

The percentages of recent doctorate recipients in each field that hold postdoctoral appointments (postdocs) primarily for continued education or training in research are included here as a labor market indicator because postdoc positions are temporary, are usually lower paid, and may be used as a way for recent doctorate recipients to maintain their professional credentials while seeking a more permanent or lucrative job. Such behavior by new doctorate recipients would be consistent with other labor market strategies that are observed, since enrollment in both graduate and undergraduate education typically goes up in bad economic times. (Discussions of aspects of postdocs that are not directly related to their significance as a labor market indicator are contained in Chapter 2, Higher Education in Science and Engineering.)

However, the variation among disciplines in the propensity of recent doctorate recipients to hold postdocs is mostly due to the differences in the traditional importance of postdocs for training new researchers in each field. Thus, the percentage of postdocs can be used only indirectly as a measure of labor market conditions. For example, the highest postdoc rates, 33.6 percent for biological scientists and 33.4 percent for physicists, are found for two groups with very different unemployment and IOF rates. (See text table 3-2.) The humanities and sociology/anthropology fields, both of which have high unemployment and IOF rates, have postdoc rates of only 2.5 percent.

Nevertheless, in fields such as physics, where a postdoc has long been an important and common career step, there are widespread reports both of increased numbers of new doctorate recipients entering postdocs and of individuals staying in postdoc positions for much longer than the traditional 1 or 2 years. Current data do not confirm that this is a common practice; yet the existence of such prolonged "apprenticeships" would increase the age when university-bound scientists first become independent researchers. It has been argued that this would reduce both the innovation and energy brought to research.[9] In addition, such prolonged academic postdocs might not be good training for doctorate recipients who may ultimately be employed in industry.[10]

Although it is not possible to examine this issue fully with the data that currently exist,[11] the existing data do not tend to support claims of dramatically increased numbers or lengths of postdoctoral appointments since the beginning of the science labor market disruptions associated with the end of the Cold War.

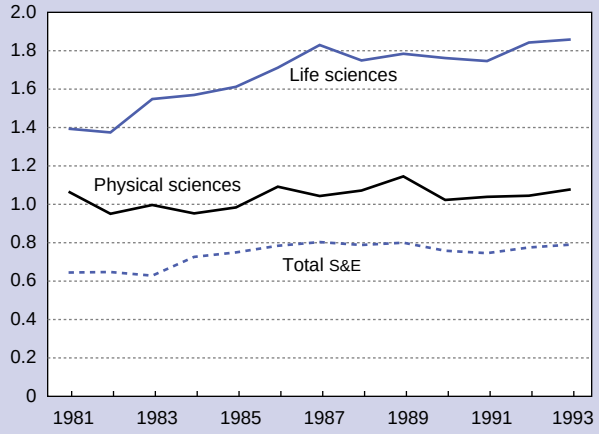
For example, data on academic postdocs are available from the NSF/National Institutes of Health Survey of Graduate Science and Engineering Students and Postdoctorates, an institutional survey sent to approximately 10,800 graduate departments. From 1981 to 1993, there has been a very close relationship between the number of new U.S. citizen postdocs and U.S. citizen doctorate recipients in the physical sciences, showing very little variation over time. (See figure 3-2 and appendix table 3-2.) For all scientists and engineers and for life scientists, this ratio has been very stable since 1986 or 1987. None of the data series shows any sign of an upturn in U.S. citizen postdocs relative to new U.S. citizen doctorate recipients since the end of the Cold War in the late 1980s.

[9]See Stephan and Levin (1992) for a discussion of age and scientific productivity.

[10]Of all U.S.-educated S&E doctorate holders, only 48.1 percent work for educational institutions of any type in any capacity.

[11]In 1991, NSF added computer-assisted telephone interviews to the data collection process for the SDR. The much higher response rate that resulted, while increasing the validity of the 1991 and subsequent SDRs, makes it difficult to look, over time, at characteristics that may be related to nonresponse. Peoples' ability to get the type of job they want may certainly affect their willingness to answer a government survey. In addition, there were changes in the wording of the question on postdocs between the 1991 and 1993 surveys.

Figure 3-2.
Ratio of U.S. citizen postdocs held to the number of new U.S. citizen Ph.D. graduates



See appendix table 3-2.

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Another data source provides somewhat contradictory indications of the trend for U.S. citizen postdocs, but it also fails to show a significant effect of the labor market changes of the late 1980s or early 1990s. The Survey of Earned Doctorates (SED) collects information on the postgraduation plans of new doctorate recipients at the time they receive their degrees. (See figure 3-3 and appendix table 3-3.) For both the physical and life sciences, this survey shows a nearly steady increase since 1970 in the proportion of those who say they have definite plans for postdoc study. Interpretation of this series is complicated by increases over time in both nonresponse to this question on the SED and in the percentage reporting no definite plans.

This indicator of flow into postdocs continued to rise through the late 1980s and early 1990s. However, there is no apparent acceleration in the late 1980s of the long-term upward trend. It is difficult to relate increases in postdoc plans to events in the labor market. For example, the percentage of new doctorate recipients in the physical sciences with definite postdoc plans actually declined in the late 1970s during the post-Vietnam defense cuts and increased during the defense buildup in the early and mid-1980s (although there was also a recession in the early 1980s). More important, the trend in the total series does not appear to fluctuate over a period with many economic or fiscal events.

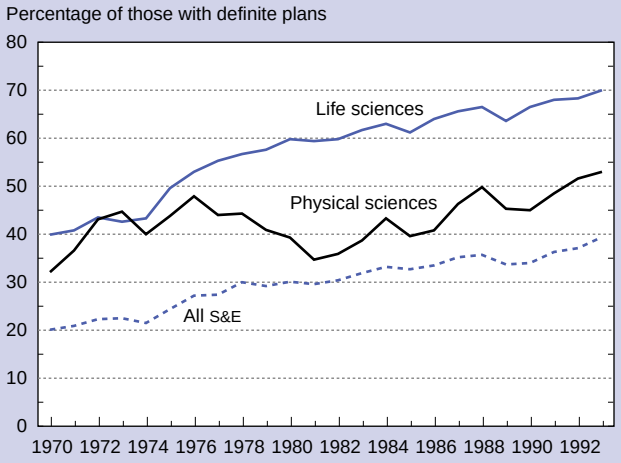
Although there are no direct data on the length of time individuals remain in postdocs, it is possible to look at the proportion of Ph.D. holders with postdocs in 1993 by the number of years since they received their degrees. In both the physical and life sciences, a very high percentage of new doctorate recipients have postdoctoral appointments in their first year after graduation—46.2 percent for the life sciences and 49.4 percent in the physical sciences. (See figure 3-4 and appendix table 3-4.) The proportion of postdocs drops rapidly for both groups with increased years since Ph.D., with life sciences reaching 4.8 percent and physical sciences, 2.6 percent after 8 years. Although recent doctorate recipients in the physical sciences have greater IOF and unemployment rates and hold more postdoc positions than doctorate holders in the life sciences, the decline in postdocs with increasing years since degree is actually more rapid. This difference is not large and could easily have resulted from institutional differences between the disciplines in the use of postdocs. However, it does not provide evidence for prolonged use of postdocs in the face of difficult labor markets.

Occupations

As discussed above, much of the concern about labor market conditions for recent S&E doctorate recipients is not about unemployment, but about whether they are able to obtain jobs that use their graduate training. A measure of this is available on the 1993 SDR, which includes a self-assessment by respondents about whether their primary jobs in 1993 are "closely," "somewhat," or "not" related to their Ph.D. fields. Individuals also reported on their occupation as of 1993 and 1988. (See text table 3-3.)

Subjective evaluations of how close a job needs to be to a Ph.D. field to be "closely related" may well differ according to expectations and institutional culture in the various academic disciplines. In addition, movement into areas judged as only "somewhat related" will be affected by the transferability of knowledge and training in a particular discipline to other areas. For this reason, the

Figure 3-3.
Proportion of new Ph.D.s with definite postdoc plans as a percentage of those with definite plans



See appendix table 3-3.

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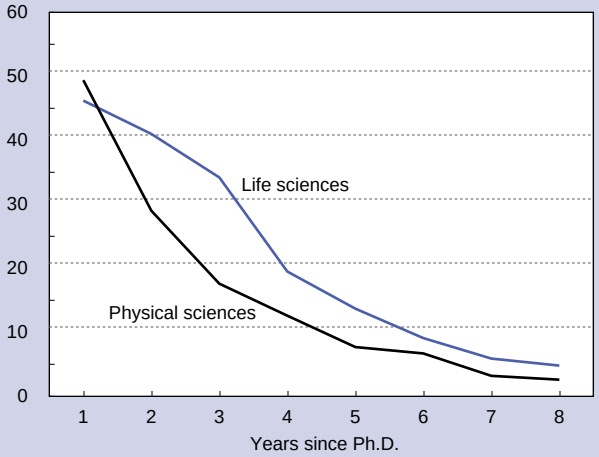
Figure 3-4.
Percent in postdoc positions, by years since Ph.D.: 1993



See appendix table 3-2.

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Text table 3-3.
Percent of Ph.D. S&E workforce working in "closely related" occupation

Field of degree	1982–87 Cohort 1988	1988–92 1993	Change 1988 to 1993
All S&E	82.1	83.4	1.3
Computer/ mathematical sciences	79.4	84.2	4.8
Computer science	83.9	86.0	2.1
Mathematical science	77.2	82.8	5.6
Engineering	76.0	76.9	0.9
Chemical engineering	76.9	78.9	2.0
Electrical/electronic engineering	70.2	76.1	5.9
Mechanical engineering	78.8	78.8	0.0
Life sciences	88.2	87.1	-1.1
Agricultural science	87.5	80.0	-7.5
Biological science	89.5	88.7	-0.8
Physical sciences	78.5	79.6	1.1
Chemistry	82.7	85.7	3.0
Geosciences	84.1	81.3	-2.8
Physics/astronomy	71.9	70.7	-1.2
Social sciences	80.7	85.1	4.4
Economics	83.0	91.0	8.0
Political science	74.0	77.9	3.9
Psychology	89.9	93.3	3.4
Sociology/anthropology	63.1	71.3	8.2

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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most valid comparison is likely to be between the two doctorate holders in the same field who graduated the same year.

In general, doctorate holders who graduated from 1983 to 1987 and from 1988 to 1992 had very similar occupational patterns. For all recent scientists and engineers, 82.1 percent of the doctorate recipients who attended from 1982 to 1987 were in closely related occupations in 1988, compared with 83.4 percent of the doctorate recipients who attended from 1988 to 1992 in 1993—a 1.3-percentage-point increase. Among specific disciplines, the greatest percentage-point decreases occurred in agricultural science (–7.5), geosciences (–2.7), and physics/astronomy (–1.2). The largest increases were in sociology/anthropology (+8.2), economics (+8.0), and electrical engineering (+5.9). Most S&E fields showed only very minor changes in the proportion of recent doctorate recipients obtaining jobs in occupations closely related to their fields.

Professional Society Data

Many professional associations conduct surveys that provide useful information about the labor markets within the fields of interest to them. These surveys are often more current than the government surveys. However, it is difficult to use them to obtain an understanding of the more general national labor market, since they vary greatly from one another in the timing and techniques of data collection and in how they word their questions. In addition, respondents may define concepts such as "employment" in a very limited context in response to a clearly identified professional association in their field.

Still, despite these caveats, data from various professional societies generally support the anecdotes of increased labor market difficulties for new doctorate recipients in many fields. The American Mathematical Society conducts a survey of recent doctoral recipients in the spring of the academic year of their degree and in the first autumn afterward. The percentage of those who, in the autumn, reported that they were "still seeking employment" rose steadily from 3.0 percent in 1989 to 10.7 percent in 1994. A similar survey by the American Institute of Physics shows an increase in the percentage of new physics doctorate recipients taking more than 6 months to find a "permanent job" from 13 percent in 1989 to 23 percent in 1992. The American Chemical Society (ACS), surveying new chemistry doctorate recipients in the summer after the academic year of their degree, found that unemployment rose from around 7.0 percent in 1989 to 17.0 percent in 1994.*

* Another 1994 ACS survey asking Ph.D. advisors about their recently graduated students found a 3.2 unemployment rate for 1994 doctorate recipients. This rate appears roughly comparable with unemployment rates generated from the SDR.

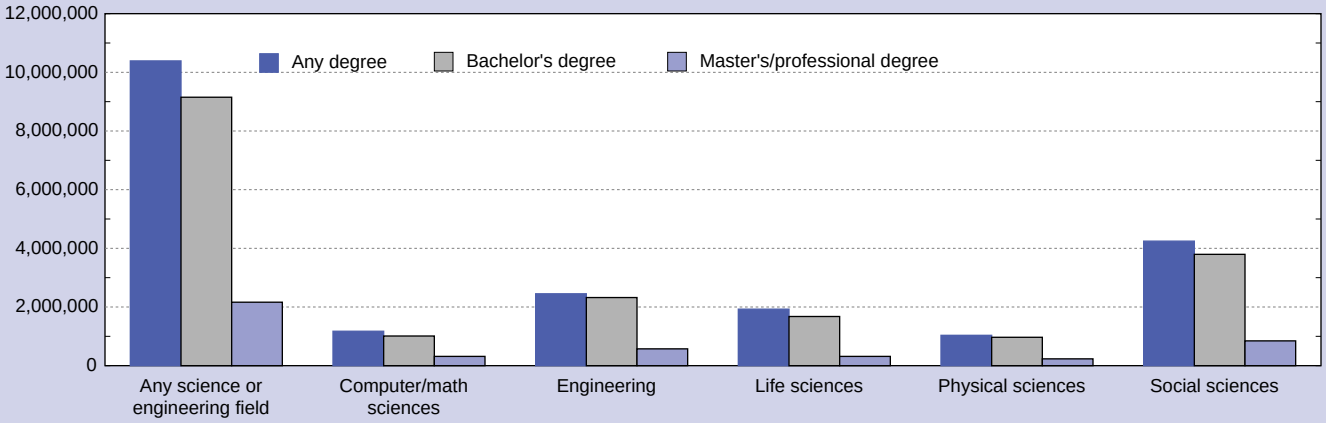
Selected Characteristics of the Science and Engineering Population

Basic Characteristics

More than 10.3 million people hold a degree in an S&E field. (See figure 3-5 and appendix table 3-5.) These estimates are according to data from the 1993 National Survey of College Graduates (NSCG).[12] Since many individuals have more than one degree in S&E, the totals across degree levels or across fields of degree are higher than the total number of individuals holding any S&E degree. Of approximately 29.0 million college graduates, 4.2 million individuals have a degree in a social sci-

[12]These are likely to be underestimates of total degrees in S&E, as the NSCG excludes individuals who did not earn a college degree prior to April 1990, but who may have subsequently earned a degree.

Figure 3-5.
Number of individuals with science or engineering degrees: 1993



NOTE: The 1993 National Survey of College Graduates excludes degrees earned after April 1990.

See appendix table 3-5.

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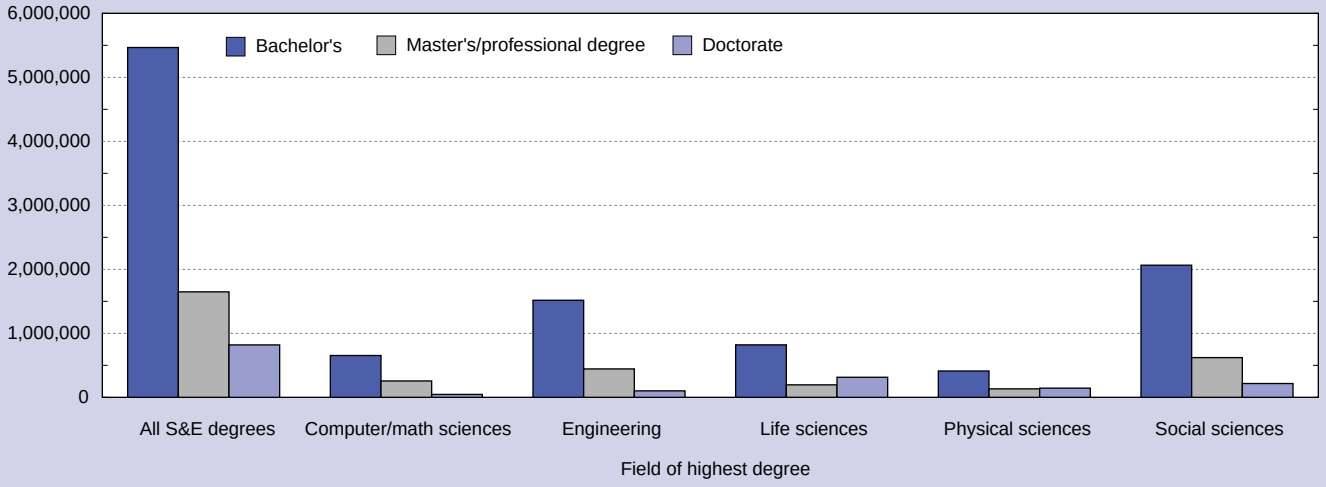
ence, 4.0 million in a natural science, and 2.5 million in engineering.

Over 7.9 million people have their highest degree in an S&E field (See figure 3-6 and appendix table 3-6). Of these, the most common degree is a bachelor's (68.9 percent), followed by master's or professional degree (20.8 percent) and doctorate (10.3 percent). Although doctorates represent only 10.3 percent of the total, they are a much larger portion of the total in the physical (20.0 percent) and life (23.6 percent) sciences. By broad field of degree, the largest S&E areas are social sciences and engineering.

Age Distribution

Age distributions for S&E degree holders are affected by historic graduation patterns, net immigration, individual advancement to higher degrees, and mortality. (See figures 3-7 to 3-9 and appendix table 3-7.) At each degree level and field of degree, the greatest population density occurs during prime productive years—the late 30s and 40s. Reflecting the lower degree production rates 30 to 40 years ago, scientists or engineers nearing traditional retirement and high mortality ages are far less numerous than those in the early stages of their careers. This implies that the number of trained scientists and engi-

Figure 3-6.
Scientists and engineers, by highest degree: 1993



See appendix table 3-6.

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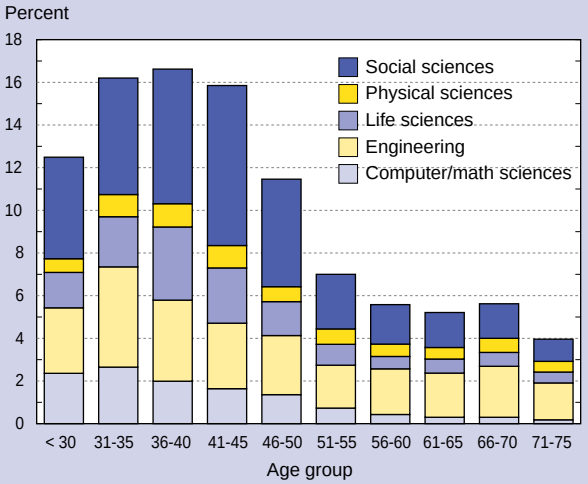
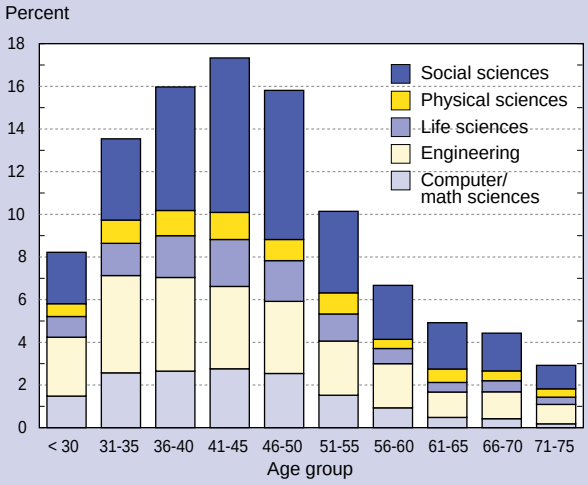
Figure 3-7.
Age distribution of bachelor's degree scientists and engineers: 1993



See appendix table 3-7. *Science & Engineering Indicators – 1996*

Figure 3-8.
Age distribution of master's degree scientists and engineers: 1993



See appendix table 3-7.

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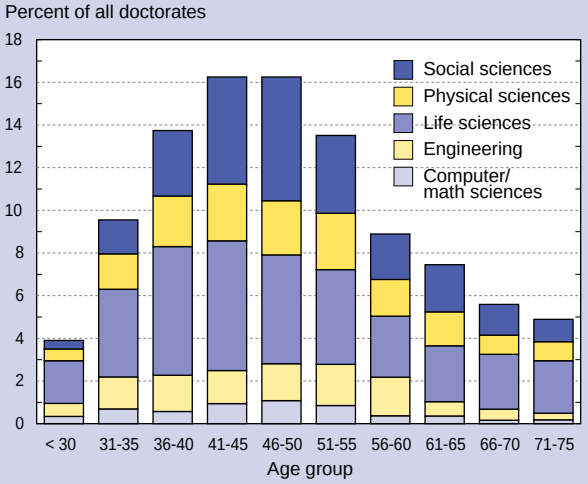
neers in the labor force would continue to increase for some time, even if degree production stayed at its current level.

Relationship Between Occupation and Education

Even at the bachelor's degree level, most people with degrees in S&E work at jobs at least somewhat related to their degrees. (See text table 3-4.) A majority (52.8 percent) of those with bachelor's degrees in engineering work as engineers; just 19.4 percent work in an unrelated non-S&E occupation. The social sciences have the lowest proportion of bachelor's graduates working in the same field as their degree, 1.5 percent, but many more work in what they describe as closely related fields; only 34.9 percent work in an unrelated non-S&E occupation.

Figure 3-9.
Age distribution of doctoral scientists and engineers: 1993



See appendix table 3-7.

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A majority of those with Ph.D.s in an S&E field work in the same field as their degree—ranging from 57.4 percent in the life and physical sciences to 74.3 percent in mathematics/computer sciences. Large numbers of S&E doctorate holders do, however, work in other fields of science or in various non-S&E occupations. Notably, in the physical sciences, 15.8 percent of doctorate holders work in some other S&E field. The percentage working in a non-S&E occupation unrelated to the field of their highest degree ranges from 8.3 percent in mathematics/computer sciences to 19.8 percent in the life sciences.

Salaries

With the sole exception of the 75th percentile for master's and professional degrees (which includes medical doctors and lawyers among the non-S&E fields), salaries are higher for S&E graduates than for non-S&E graduates at each degree level and at each point in the salary distribution. (See text table 3-5.) This is true even in the relatively lower paying life and social sciences fields. S&E doctorate holders earn 23.0 percent more than those with master's/professional S&E degrees and 42.9 percent more than those with bachelor's S&E degrees.[13]

Median salaries for doctorate holders in science and engineering rise steadily with the number of years since

[13]This is not an analysis of whether a Ph.D. is a good investment in purely financial terms. That would have to include a consideration of the direct costs of education and foregone earnings while undertaking graduate study.

Text table 3-4.
Occupational characteristics of individuals with degrees in science and engineering: 1993

	Occupation category				
	Same field	Other S&E	Closely related non-S&E	Somewhat related non-S&E	Unrelated non-S&E
	Percent				
Bachelor's degree					
Computer/mathematical sciences	35.3	3.9	12.9	16.5	31.4
Engineering	52.8	5.9	8.7	13.2	19.4
Life sciences	10.0	7.1	25.6	20.8	37.0
Physical sciences	22.1	17.7	20.8	22.3	25.2
Social sciences	1.5	4.2	32.1	27.4	34.9
Master's/professional degree					
Computer/mathematical sciences	44.8	7.2	5.2	13.0	29.8
Engineering	57.8	10.5	5.3	10.8	15.6
Life sciences	28.4	8.3	11.3	12.7	39.3
Physical sciences	43.2	18.5	9.3	9.0	20.0
Social sciences	19.3	4.0	13.1	16.9	46.7
Doctoral degree					
Computer/mathematical sciences	74.3	5.7	3.8	8.0	8.3
Engineering	59.9	12.0	4.5	11.1	12.6
Life sciences	57.4	6.1	5.2	11.5	19.8
Physical sciences	57.4	15.8	6.5	11.1	9.2
Social sciences	63.3	5.9	4.5	10.8	15.5

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *1993 National Survey of College Graduates*, unpublished tabulations; and SRS, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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Text table 3-5.
Distribution of annual salaries, by field and level of highest degree: 1993

		All S&E	Computer/ mathematical science	Engineering	Life sciences	Physical sciences	Social sciences	Non-S&E
		Dollars						
Bachelor's degree	25th percentile	30,000	33,000	40,000	27,000	32,000	26,000	26,000
	Median	42,000	44,100	51,000	36,000	43,700	35,400	35,700
	75th percentile	57,200	57,600	65,000	48,000	60,000	50,000	52,000
Master's/ professional degree	25th percentile	35,500	41,000	46,200	30,000	37,000	30,000	33,000
	Median	48,800	52,200	58,200	40,000	50,300	40,000	46,000
	75th percentile	65,000	70,000	72,000	51,700	69,800	54,000	68,400
Doctoral degree	25th percentile	43,000	46,200	53,500	40,000	49,000	40,000	37,000
	Median	60,000	60,600	70,000	60,000	64,800	52,700	49,000
	75th percentile	82,000	73,000	89,000	90,000	80,000	72,000	65,000

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 National Survey of College Graduates*, unpublished tabulations.

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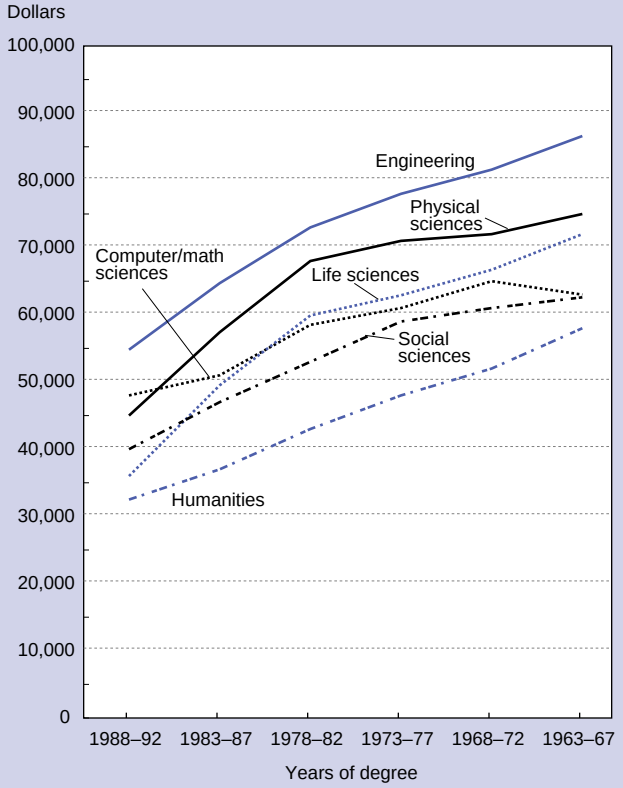
completion of the doctoral degree. Even in the lowest paying S&E doctoral field, the social sciences, salaries remain significantly higher than for doctorate holders in the humanities throughout the career cycle. (See figure 3-10 and appendix table 3-8.)

Women in the Science and Engineering Labor Force

The proportion of women among doctorate holders in the S&E labor force is much greater for more recent graduation cohorts. (See text table 3-6.) For each broad S&E field, the proportion of women among 1983–92 grad-

Figure 3-10.
Median Ph.D. salaries, by year of degree: 1993



See appendix table 3-8.

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uates is more than triple the proportion among pre-1973 doctorate holders. However, this growth is often from a very small base. For example, among pre-1973 engineering doctorate recipients in the labor force, only 0.2 percent are female. This rises to 8.8 percent female for 1983–92 engineering doctorate recipients. In social sciences and the life sciences, the proportion of female doctorate recipients is far greater—rising to 46.4 percent among 1983–92 Ph.D. graduates in the social sciences and 37.2 percent in the life sciences. For these two fields, the increase in the proportion of female doctorate recipients between graduation cohorts is similar to the increase in the humanities, which was from 17.9 percent for the pre-1973 cohort to 41.1 percent for 1983–92 graduates.

Another source of data on trends in the participation of women in the S&E labor force is the decennial census. Between 1980 and 1990, the proportion of women in nonacademic S&E occupations rose from 12.6 percent to 22.2 percent.[14] (See text table 3-7.) This increase occurred in all occupational fields. Among engineers, the percentage of females increased from 4.4 percent in 1980 to 9.2 percent in 1990. A majority (51.4 percent) of nonacademic social scientists in 1990 were female.

Across all S&E fields, female doctorate holders earn between 13 and 20 percent less than male doctorate holders in the same fields. Much of this difference is due to the younger age distribution of female doctorate holders. However, even when comparing salaries of males and females from the same graduation cohorts, median salaries of female doctorate holders are slightly less than the salaries for male doctorate holders. (See text table 3-8.) Median salaries of 1988–92 female doctorate recipients ranged from 91.2 percent of the male median salary for mathematics/computer science doctorate recipients

[14]This was first published in NSF 95-306 "Nonacademic Scientists and Engineers: Trends from the 1980 and 1990 Censuses" (1995). Scientists and engineers can be identified in U.S. Census data only through self-described occupations; the data include individuals with all levels of education.

Text table 3-7.
Percentage female of nonacademic scientists and engineers on the decennial census: 1980 and 1990

	1980	1990
All scientists and engineers	12.6	22.2
Computer/mathematical scientists	25.9	36.2
Engineers	4.4	9.2
Life scientists	25.6	32.5
Physical scientists	16.2	22.7
Social scientists	38.1	51.4

SOURCE: Science Resources Studies Division, National Science Foundation, *Nonacademic Scientists and Engineers: Trends from the 1980 and 1990 Censuses,* NSF 95-306 (Arlington, VA: NSF, 1995).

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Text table 3-6.
Proportion of U.S. educated Ph.D.s in the labor force that are female, by year of degree: 1993

	Graduation year			
Field of degree	All years	Before 1973	1973–82	1983–92
Computer/mathematical sciences	12.1	5.6	12.5	17.3
Engineering	4.4	0.2	3.1	8.8
Life sciences	25.7	11.7	23.2	37.2
Physical sciences	10.1	3.9	8.7	18.7
Social sciences	33.1	15.0	31.0	46.4
Humanities	31.2	17.9	33.0	41.1

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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Text table 3-8.
Median salary of female Ph.D.s as a percentage of male Ph.D.s: 1993

Field of degree	Graduation year					
	All years	Before 1973	1973–77	1978–82	1983–87	1988–92
Computer/mathematical sciences	87.4	90.9	100.0	97.2	102.0	91.2
Engineering	83.6	119.0	108.6	97.3	95.4	96.4
Life sciences	81.0	85.7	83.1	88.6	96.0	98.9
Physical sciences	80.0	80.0	96.9	95.6	94.8	92.9
Social sciences	83.8	87.5	91.7	90.9	93.8	98.0
Humanities	85.1	93.5	96.2	96.0	94.9	95.7

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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to 98.9 percent of the male median salary for life science doctorate recipients. With the noteworthy exception of engineering,[15] female doctorate holders' salaries are closer to male salaries for the 1988–92 graduation cohort than for the pre-1973 cohort.

[15]Many models in labor economics assume that if there is an added cost, pecuniary or nonpecuniary, to enter a particular labor market, only the most able will enter. Given the extremely small number of pre-1973 female Ph.D.s in engineering, this may be one explanation for the higher female salaries.

Racial/Ethnic Minorities in the Science and Engineering Labor Force

Compared with women, there have been less dramatic, but still steady gains in the representation of racial and ethnic minorities in science and engineering. The proportions of blacks, Hispanics, and Asians[16] among doctorate holders in the S&E labor force are compared in this section. (See text table 3-9.)

[16]"Asian" refers here to the Asian/Pacific Islander racial group, based upon self-identification on the U.S. Census and various NSF surveys. It does not refer to place of birth, as it does in a later discussion of immigrants in this chapter.

Text table 3-9.
Proportion of racial/ethnic minorities among U.S. educated Ph.D.s in the labor force, by year of degree: 1993

Field of degree	Graduation year			
	All years	Before 1973	1973–82	1983–92
Black				
Computer/mathematical sciences	1.4	1.0	1.7	1.6
Engineering	1.3	0.2	2.0	1.7
Life sciences	1.9	1.1	2.0	2.4
Physical sciences	1.1	0.6	1.3	1.4
Social sciences	3.5	1.6	3.7	4.6
Humanities	2.0	0.9	2.5	2.4
Hispanic				
Computer/mathematical sciences	2.6	1.9	2.9	3.0
Engineering	1.9	1.0	2.1	2.4
Life sciences	1.8	1.6	1.1	2.5
Physical sciences	1.9	1.2	1.8	2.8
Social sciences	2.4	1.4	1.8	3.7
Humanities	3.2	2.1	3.4	4.1
Asian				
Computer/mathematical sciences	15.2	6.7	10.5	26.2
Engineering	25.4	13.2	26.1	34.8
Life sciences	8.7	6.3	7.6	11.3
Physical sciences	12.4	6.7	12.0	19.5
Social sciences	3.9	2.7	2.8	5.6
Humanities	3.2	2.7	2.4	4.7

SOURCE: Science Resources Studies Division, National Science Foundation, *1993 Survey of Doctorate Recipients*, unpublished tabulations.

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The representation pattern is very similar for black and Hispanic doctorate holders in the S&E labor force. For blacks, the greatest representation is 3.5 percent among social science doctorate holders, and the lowest is 1.1 percent among physical science doctorate holders. For each broad S&E doctoral field, blacks are better represented in the most recent cohort than in the field as a whole. However, even among the 1983–92 cohort, the percentage of black doctorate holders ranges from only 1.4 percent in the physical sciences to 4.6 percent in the social sciences. For Hispanic doctorate holders, representation ranges from 1.8 percent in the life sciences to 2.6 percent in the mathematical and computer sciences. As with blacks, Hispanics are only slightly better represented among more recent Ph.D. cohorts, but they show gains within each broad S&E field.

Asian doctorate holders, both U.S. and foreign-born, are a much larger proportion of the S&E labor force than other minority groups. Asians represent 25.4 percent of U.S.-educated doctorate holders in engineering in the labor force, 15.2 percent in mathematics/computer sciences, 12.4 percent in the physical sciences, 8.7 percent in the life sciences, and 3.9 percent in the social sciences. Their proportion of the 1983–92 graduation cohort is larger for each broad S&E field, ranging from 5.6 percent in the social sciences to 34.8 percent in engineering.

A similar representation pattern is found for blacks and Hispanics (and, to a more modest extent, Asians) looking at all education levels of those with S&E occupations on the 1980 and 1990 censuses (NSF, 1995). The proportion of blacks increased from 3.2 to 4.4 percent between 1980 and 1990; Hispanics increased from 2.2 to 3.1 percent; and Asians increased from 4.2 to 6.0 percent of all those with S&E occupations.

Industrial Science and Engineering Job Patterns

In 1993, U.S. industry provided jobs for approximately 2 million scientists and engineers.[17] (See appendix table 3-9.) These scientists and engineers represented 2.0 percent of all industry employment, up slightly from 1.9 percent in 1984. Since the 1950s, industrial employment patterns for scientists and engineers have shifted significantly, with strong growth in the 1950–70 period, stagnation and decline in the early and mid-1970s, resurgence in the late 1970s and 1980s, and generally falling rates of growth in the early 1990s.

While the overall number of S&E jobs in industry increased by about 2.5 percent between 1990 and 1993, employment in most S&E occupations declined. The principal factor contributing to the increase in total industrial S&E employment in the early 1990s was the growth in the number of computer- and mathematics-related jobs. These jobs accounted for 28 percent of industrial S&E employment in 1993, up from 21 percent in 1990.

Manufacturing Industries

In 1993, about 263,000 scientists and 613,000 engineers—44 percent of the total industrial S&E labor force—were employed in manufacturing industries. Between 1990 and 1993, employment in science occupations increased at an average annual rate of 3.5 percent per year, while engineering employment declined at an average rate of 4 percent annually. Total manufacturing employment dropped by 2.3 percent per year.

In general, the decline in engineering employment in manufacturing in the early 1990s was across the board. Four of the five largest engineering specialties and the five manufacturing industries employing the largest numbers of engineers declined between 1990 and 1993. The largest percentage cutback was in aeronautical/astronautical engineering (33 percent). The entire loss appears to have occurred in the transportation equipment industry, which is the largest employer of aeronautical/astronautical engineers. Many of these engineers were working for aircraft and missile companies and were assigned to defense-related projects that are being curtailed or eliminated (BLS, 1994).

Job losses in industrial engineering numbered 16,000 between 1990 and 1993, about the same as in aeronautical/astronautical engineering. (See figure 3-11.) The transportation equipment industry, the largest employer of industrial engineers in the late 1980s and early 1990s, accounted for 75 percent of the decrease in industrial engineering jobs in manufacturing (BLS, 1994).

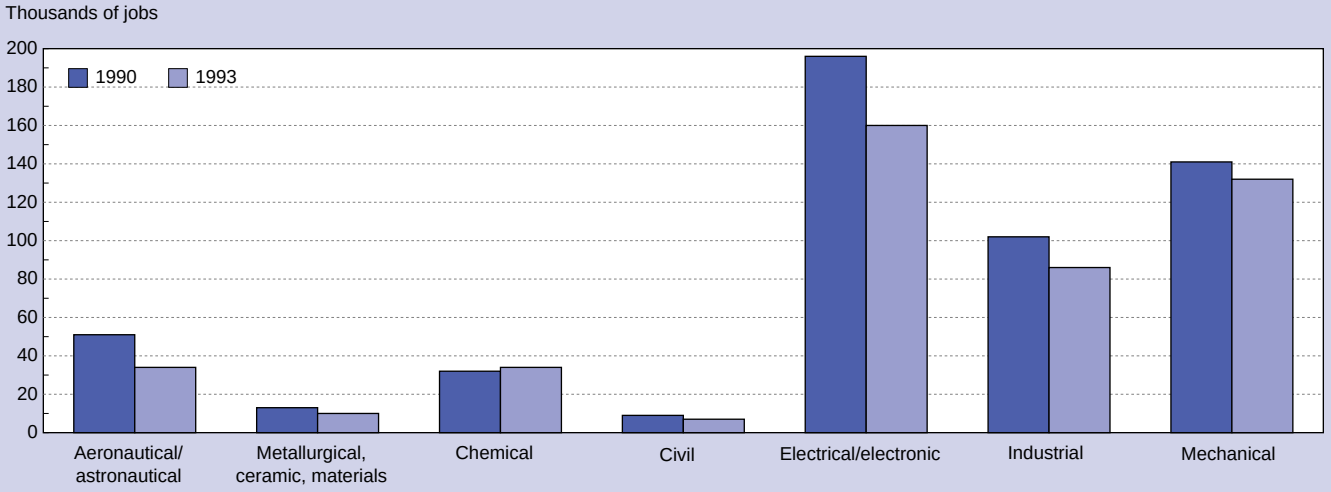
Between 1990 and 1993, 36,000 electrical/electronics engineering jobs were lost, the largest absolute decline of any engineering specialty. The largest cutbacks were, again, in the transportation equipment industry, the electrical equipment industry, and the instruments and related products industries. However, many of these job losses were probably offset by increases in computer- and mathematics-related jobs (especially computer engineering, which is very closely related to electrical/electronics engineering).

Unlike engineering, the total number of scientists' jobs in manufacturing increased during the early 1990s. Growth in science occupations was attributable to increases in life science and computer/mathematics occupations. There were approximately 26,000 more scientists working for manufacturing firms in 1993 than in 1990. (See appendix table 3-9.) During that 3-year period,

[17]Analyses in this section are based on data from the U.S. Bureau of Labor Statistics' (1994) *National Industry-Occupation Employment Matrix 1983–1993 Time Series.* Data in the matrix were based on information collected from the BLS Occupation Employment Statistics surveys. This large, establishment-based survey collects information on employment in S&E jobs. The individuals holding these jobs need not be formally trained in S&E but rather can have the equivalent of 4 years of training in a related S&E field.

Note that the Occupational Employment Survey (OES) data do not necessarily classify S&E personnel engaged in management as part of the S&E workforce. In the OES survey, management is a unique occupation; in other surveys referenced in this chapter, management is a permissible S&E job function.

Figure 3-11.
Number of jobs in manufacturing for selected engineering specialties



See appendix table 3-9.

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the number of life scientists increased by 4,000, while the number of jobs in computer and mathematics related specialties rose by 26,000.

Nonmanufacturing Industries

In 1993, the nonmanufacturing industry sector provided jobs for an estimated 1,130,000 scientists and engineers, or 56 percent of total industrial S&E employment. (See appendix table 3-9.) The majority of the sector's S&E employees were in science occupations—634,000 versus 496,000 engineering jobs. Most of these scientists and engineers were in the service-producing industries and a small proportion were in mining and construction. S&E employment in nonmanufacturing industries increased moderately during the early 1990s at an average annual rate of 3.2 percent. This increase can be attributed to two main factors:

- A greater share of industrial S&E jobs were located in the nonmanufacturing sector in 1993 versus 1990, and
- The nonmanufacturing sector, unlike the manufacturing sector, experienced general economic growth with attendant increases in overall total employment.

Total employment in nonmanufacturing industries grew at an average annual rate of slightly less than 1 percent between 1990 and 1993, while the proportion of the nonmanufacturing workforce in S&E positions increased during this time from 1.3 percent to 1.4 percent.

The major nonmanufacturing industries in terms of S&E employment in 1993 were

- Engineering and management services (455,000 S&E jobs);
- Business services (239,000 S&E jobs); and
- Financial services (125,000 S&E jobs).

Together, these industries provided over two-thirds of all S&E jobs in the nonmanufacturing sector (SRS, forthcoming [c]).

Similar to the decline in engineering employment in the manufacturing sector in the early 1990s, the number of engineering jobs in the nonmanufacturing sector declined by 6 percent between 1990 and 1993. Most of the loss occurred in the engineering and management services industries. Meanwhile, the number of science occupations in the nonmanufacturing sector increased by 26 percent between 1990 and 1993. The computer and mathematics-related specialties were largely responsible for this growth; the number of jobs in these fields increased by more than 50 percent during that period.

Federal Employment of Scientists and Engineers

Although Federal government agencies employed only a fraction (about 1.5 percent) of all employed scientists and engineers in 1993, they are worth examining as a group for two reasons: They play strategic roles in Federal R&D funding and regulatory activities and they exemplify public policy in the deployment of persons with advanced training.

Employment of Federal scientists and engineers rose from 185,623 in 1989 to 196,908 in 1993. (See text table 3-10.) This change represents an increase of 6 percent over 4 years. Scientists and engineers employed in S&E jobs in the general U.S. economy increased by an estimated 11 percent. By comparison, overall U.S. Federal employment during the 1989–93 period increased by

Text table 3-10.
Federal scientists and engineers, by major occupational group: 1989–93

Occupation	1989	1990	1991	1992	1993
Total, all S&E occupations	185,623	189,049	194,726	198,853	196,908
All scientists	89,530	92,467	96,919	101,006	101,348
Computer & mathematical scientists	25,737	26,725	28,210	29,371	29,691
Life scientists	23,082	24,009	25,280	26,765	26,920
Physical scientists	23,204	23,725	24,140	24,427	24,118
Social scientists	17,507	18,008	19,289	20,443	20,619
All engineers	96,093	96,582	97,807	97,847	95,560
Aerospace engineers	8,433	8,624	8,777	8,584	8,330
Chemical engineers	1,503	1,413	1,344	1,311	1,245
Civil engineers	13,945	13,621	13,357	13,231	12,874
Electrical, electronics, & computer engineers	31,121	31,899	32,753	32,955	32,374
Industrial engineers	3,463	3,419	3,173	3,016	2,725
Mechanical engineers	12,186	11,787	11,763	11,532	11,159
Other engineers	25,442	25,819	26,640	27,218	26,853

SOURCE: National Science Foundation, OPM Central Personnel Data File.

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only 1.5 percent. In 1989, scientists made up 48 percent and engineers made up 52 percent of the Federal S&E workforce. By 1993, the percentage of scientists (51 percent) had surpassed the percentage of engineers (49 percent). Among Federal scientists during the 1989–93 period, social scientists showed the largest growth (17.8 percent), followed by life scientists (16.6 percent), computer and mathematical scientists (15.4 percent), and physical scientists (3.9 percent).

Overall Federal employment of engineers decreased by 0.6 percent during this period. Among the major engineering occupational groups, the change in employment ranged from an increase of 4.0 percent for electrical, electronics, and computer engineers to a decrease of 17.2 percent for chemical engineers.

Agency of Employment

Between 1989 and 1993, the rise in Federal S&E employment varied by agency. The largest decreases during the period occurred within the Department of Defense (DOD) (2,031). (See text table 3-11.) In 1993, 46.8 percent of all Federal scientists and engineers were employed at DOD, down from 50.7 percent in 1989. This change was due in good part to the reductions in defense spending from 1989 to 1993. The 4-year growth for all other agencies was 14.6 percent; they increased their share of all Federal S&E employment from 49.3 percent in 1989 to 53.2 percent in 1993.

Work Activities

Federal scientists and engineers changed their work activities during the 1989–93 period. (See appendix table 3-10.) The percentage of scientists and engineers report-

Text table 3-11.
Employment change and four-year growth rate of Federal scientists and engineers, by selected agency: 1989–93

	4-year growth rate	Employment change
	— Percent —	— Number —
Total	6.1	11,285
Department of Agriculture	5.3	889
Department of Commerce	12.8	998
Department of Defense	–2.2	–2,031
Department of the Army	–4.7	–1,657
Department of the Navy	–3.6	–1,426
Department of the Air Force	–1.3	–221
Other defense agencies	34.8	1,273
Department of Energy	33.7	1,294
Department of Health & Human Services	18.4	1,493
Department of Housing & Urban Development	12.8	50
Department of the Interior	13.5	1,604
Department of Justice	63.6	1,004
Department of Labor	13.2	250
Department of State	18.2	524
Department of Transportation	19.3	882
Department of the Treasury	37.6	945
Department of Veterans Affairs	21.7	954
Environmental Protection Agency	24.0	1,558
General Services Administration	32.0	237
National Aeronautics & Space Administration	4.2	504
National Science Foundation	–13.0	–49
Nuclear Regulatory Commission	9.3	136
U.S. International Development Coop Agency	–19.7	–115
All other agencies	5.0	158

SOURCE: National Science Foundation, OPM Central Personnel Data File.

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ing primary work activities associated with defense design, production, and construction activities decreased during this period. Research, development, test and evaluation, and data collection processing and analysis are primary work activities showing less relative participation in Federal S&E employment during 1989–93. However, throughout the period, development and research continued to be the largest work activities for Federal scientists and engineers.

Demographics

During the 1989–93 period, the Federal S&E workforce aged significantly and dramatically increased the proportions of female scientists and engineers. In 1989, 25.1 percent of the scientists employed by the Federal Government were under the age of 35, and 10.6 percent were 55 years of age or older. By 1993, only 22.6 percent of the scientists were under the age of 35, and 11.5 percent were 55 years of age and older. (See appendix table 3-11.) The same trend held for engineers. Ethnic/racial minorities also significantly increased their share of Federal S&E employment.

The number of female scientists and engineers employed in the Federal Government increased dramatically by 27 percent between 1989 and 1993: from 29,328 to 37,341. (See appendix table 3-12.) In contrast, the number of male scientists and engineers grew by only 2 percent over the same period. Despite higher growth rates for women, in 1993 females accounted for only 27.3 percent of all Federal scientists and 10.1 percent of all Federal engineers, up from 23.6 percent and 8.6 percent in 1989, respectively (SRS, forthcoming [a]).

The number of Federal scientists and engineers who are members of ethnic/racial minority groups rose from 26,052 in 1989 to 30,810 in 1993. (See text table 3-12.) Most of this increase is attributed to the 20.9 percent increase in the number of Asians, who rose from 9,866 to 11,930 during the period. In contrast, the number of black scientists and engineers increased by 15.1 percent and the number of Native Americans grew 34.4 percent. Hispanics showed a 19.9 percent increase, rising from 5,331 in 1989 to 6,394 in 1993.

Salaries

From 1989 to 1993, the median annual base salaries of Federal scientists and engineers increased 21.9 percent from $41,100 to $50,100, a higher rate of increase than the annual average weekly earnings increase in national private nonagricultural industries, which rose only 12 percent during the same period. (See appendix table 3-13.) This increase may be accounted for by increases in the age, experience, and education levels of the Federal S&E workforce. The median salaries for engineers are 24.5 percent higher than those for scientists, and the percent change in salaries for engineers outpaced that for scientists (19.1 percent).

Supply and Demand Outlook for Science and Engineering Personnel

Projecting supply and demand for S&E personnel is not without risks. Few people would have predicted the end of the Cold War in the late 1980s or the explosive expansion of the Internet in the 1990s. It is similarly difficult to anticipate other changes in national priorities that may affect employment for S&E personnel. Projections of future labor market conditions are dependent on the economic assumptions used, and therefore, can be incorrect if conditions change. This section provides several different growth scenarios, as well as information on the economic assumptions underlying them, in an attempt to provide a useful way to think about possible employment outcomes for S&E trained personnel.

This section presents findings of an analysis conducted by Dr. Robert Dauffenbach of the University of Oklahoma.[18] The objectives of the study were twofold:

[18]Estimated employment growth for the study was generated by Data Resources, a private economic forecasting firm. The supply projections, perhaps the distinctive feature of this analysis, were based on a model that incorporates all major sources of response to changes in demand. Developed by Dr. Robert Dauffenbach (University of Oklahoma) with support from NSF, these projections are intended to identify potential problems within the S&E labor market, as well as to assist in understanding the dynamics and flexibility of S&E labor supply.

Text table 3-12.
Federal scientists and engineers, by racial/ethnic status: 1989–93

Racial/ethnic status	1989	1990	1991	1992	1993
Total	185,623	189,049	194,726	198,853	196,908
White	159,401	161,431	165,564	168,316	166,084
Black	8,409	8,712	9,216	9,579	9,682
Asian	9,866	10,565	11,192	11,764	11,930
Hispanic	5,331	5,687	6,071	6,354	6,394
Native American	929	1,002	1,106	1,198	1,249
All other	1,517	1,576	1,523	1,516	1,555
No report	170	76	54	126	14

SOURCE: National Science Foundation, OPM Central Personnel Data File, unpublished tabulations.

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first, to estimate the change of S&E personnel requirements during the 11-year period between 1994–2005; second, to assess the adequacy of the projected supply of such personnel available to meet those requirements. The model presented here represents one of several possible approaches to examining the outlook for S&E personnel. Equally robust models with different assumptions about demographic trends, or incorporating different personnel populations, job mobility, and other factors are likely to yield different results. Therefore, in providing this information, the National Science Board and the National Science Foundation are not endorsing a particular outcome, but rather are presenting several scenarios to examine and provide information on how various factors affect the dynamics of the S&E labor market.

According to the study, the next decade should be a period of relative stability in S&E labor markets, particularly as compared with the employment declines experienced by S&E workers in the early 1990s. This conclusion has been reached after a careful examination of the following:

- A range of likely demand scenarios to determine how alternative national economic growth patterns might affect S&E employment, and
- Supply side simulations to test the ability of the supply system to respond to these various demand scenarios.

The supply and demand models used to produce these simulations try systematically to account for the many institutional features, individual behavior patterns, demographic trends, and economic forces that govern S&E labor markets (Leslie and Oaxaca, 1991). Results and features of these models are provided in this section. Since it is not possible to predict with certainty how the economy will change over time, a range of outcomes is modeled, within which the actual S&E requirements are likely to fall.

Operations of the Science and Engineering Labor Market

The performance of the U.S. economy is the major determinant of current and future demand for scientists and engineers. It is important to understand the basic operations of the economy in generating jobs for scientists and engineers (see *Science and Engineering Employment: Projecting the Demand Side*) and in filling those jobs through education and training institutions (see *Science and Engineering Employment: Projecting the Supply Side*). The models upon which the following results are based attempt to capture these fundamental operations systematically. In this manner, alternative scenarios about the future and the ability of the supply system to meet such contingencies can be examined and assessed.

Projected Demand for Science and Engineering Personnel

As described above, projections are forecasts that are conditional upon a variety of assumptions. These assumptions depict expected economic, institutional, and social conditions. The analysis in this section was, therefore, designed not to provide a single numeric estimate of future employment requirements, but, instead, to provide a range within which employment growth is likely to occur during the 1994–2005 period.

In total, three projections scenarios—a low, a mid, and a high—were analyzed with the demand model, using alternative sets of economic assumptions[19] designed to encompass likely economic performance during the simulation period 1994–2005. (See the summary shown in

[19]DRI generated these projections of scientist and engineer requirements. The economic assumptions used by the three projection scenarios—low, mid, and high—were also provided by DRI. The scenarios were run in the summer of 1995. Based on these assumptions, DRI generated estimates of projected growth in total employment demand by sector. The U.S. Bureau of Labor Statistics occupational structure was applied to the total employment projections where necessary.

Science and Engineering Employment: Projecting the Demand Side

From the demand perspective, projecting requirements for S&E personnel begins with "final industry demand"—the output of goods and services from the various agriculture, mining, manufacturing, and service industries that is available for purchase by households, businesses, government, and foreigners. Because industries buy raw materials, products in intermediate stages of production, and services from other industries, the total volume of production in a given industry exceeds the total available for final purchase. *Final demand* in the various industries, thus, needs to be translated into *total output* per industry.

Once future total industry output is estimated, productivity ratios—that is, output divided by labor input—can be used to estimate employment demand by industry. From there, total industrial employment can be broken into its occupational employment components. This translation is accomplished through use of the projected occupational employment distribution per industry—the percentage of employment demand for scientists and engineers, managers, clerical employees, and blue-collar workers. Summing the resulting employment by occupation across industries yields total projected occupational demand. Thus, through such models, it is possible to translate alternative final demand patterns into projected estimates of total demand by occupation. Whether or not there will be a sufficient number of adequately trained workers to fill the potential demand projected by the models depends on the supply of such workers.

Science and Engineering Employment: Projecting the Supply Side

Many factors must be considered on the supply front. A large amount of attention is typically paid to the production of S&E college degrees at both the baccalaureate and graduate levels. Underlying demographic trends of prime college-age groups, their rates and trends in college attendance, their willingness to pursue S&E degrees, and their willingness to work in S&E jobs once they graduate must also be examined. Recent college graduates represent a flow of new S&E personnel into the supply system. (See Labor Market Experience: Recent Science and Engineering Bachelor's and Master's Graduates in this chapter.)

These flows of newly trained personnel are much smaller than the stocks of employed persons in various S&E occupations. (See National Science Board (NSB) 1989, pp. 77–80, for an extensive discussion of S&E labor market stocks and flows.) The stocks of employed persons in S&E occupations, in turn, are smaller than the total number of personnel with S&E training in the workforce. Take, for example, engineers. In 1989, there were 67,200 bachelor's degrees awarded in engineering and about 1.6 million people employed in engineering jobs (not all of whom had engineering degrees). Consequently, small changes in the behavior of experienced workers can have dramatic supply consequences. Supply models must capture the behavior of experienced workers through analysis of the longevity of S&E careers. Such models must also take into account the willingness and ability of S&E-trained personnel to work in occupations that do not exactly match their training (Dauffenbach, 1990). This latter concept is known as field mobility.

Text table 3-13.
Summary statistics for macroeconomic senarios: 1994–2005

Indicators	1990–94	1994–2005 Macroeconomic scenarios Low	Mid	High
		Average annual real growth (percent)		
GNP	2.1	1.7	2.5	3.2
Consumption	2.3	1.5	2.3	2.9
Business fixed investment	5.1	3.3	4.4	5.5
Exports	6.5	6.5	7.3	8.0
Imports	7.9	5.4	6.3	7.2
		Average annual growth (percent)		
Labor force	1.2	1.1	1.4	1.6
Productivity	1.9	0.9	1.4	1.9
Industrial production	2.7	2.0	2.9	3.6
		Average level (percent)		
Inflation (GNP deflator)	2.7	4.3	2.6	1.6
Unemployment	6.8	6.5	6.0	5.7

NOTES: Growth rates for the projection period are compound annual growth rates calculated between the years 1994 and 2005. Level variables are averages for the years 1995 to 2005.

SOURCES: Data Resources (DRI)/McGraw Hill, unpublished tabulations.

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Text table 3-14.
Projected science and engineering employment growth 1994–2005, under alternative scenarios

Occupational group	Scenarios Low	Mid	High
	Percent change		
All occupations	12	16	20
Total scientists and engineers	32	46	62
Computer and math specialists	66	82	104
Engineers	19	34	49
Life scientists	15	23	36
Physical scientists	-3	4	14
Social scientists	15	22	28

SOURCE: Data Resources (DRI)/McGraw Hill, unpublished tabulations.

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text table 3-13.) Aggregate growth in demand for S&E personnel varies considerably under the three alternative economic growth scenarios. (See text table 3-14.)[20]

- ♦ Low growth—S&E employment is expected to expand by 32 percent;
- ♦ Mid growth—S&E employment is expected to expand by 46 percent; and
- ♦ High growth—S&E employment is expected to expand by 62 percent.

(The scenarios are not predictions; consequently, departures from the assumptions on which the scenarios are based may alter future outcomes significantly.) By way of comparison, total employment is projected to grow by approximately 16 percent under the mid-growth scenario. Widely varying differentials in growth are expected among the five broad groupings of S&E employment: engineers, mathematics and computer specialists, life scientists, physical scientists, and social scientists. Under the mid-growth scenario, for example, engineering employment is expected to rise by almost

[20]The projected changes in employment demand in this section are based on data from the U.S. Bureau of Labor Statistics (BLS) Current Population Survey. Projected employment changes from the BLS for the same period (1994–2005) are based on the BLS Occupation Employment Statistics establishment surveys. Because of these differences, the growth rates presented here may differ from those presented by BLS for the 1994–2005 period. Additionally, the DRI model incorporates a dynamic link to R&D expenditures which typically has a disproportionate impact on demand for S&E personnel.

35 percent between 1994 and 2005, while physical science employment is expected to increase by roughly 4 percent. Mathematics and computer science employment is expected to grow by more than 80 percent. Demand for life scientists and social scientists is projected to increase by 23 percent and 22 percent, respectively.

Supply-Side Responses

There are many avenues for correcting labor market imbalances generated by disparate growth patterns, including the following:

- More students can pursue college degrees and major in high-growth occupational specialties and fewer will enter training in low-demand specialties;
- Recent graduates with related degrees can seek additional training to qualify in high-growth employment categories;
- Early retirement can occur in cases of excess supply; postponements, in cases of excess demand;
- Personnel standards can be relaxed when excess demand develops;
- Personnel can be retrained and occupationally upgraded;
- Migrants from abroad can lessen supply/demand differentials in high-demand areas; and
- Individuals educated and trained in S&E fields that are in excess supply may have to seek alternative careers.

The supply model seeks to capture these various facets of flexibility in system operations. However, the amount of flexibility the supply model exhibits must be based on historical magnitudes (Collins, 1988).

Supply model simulations were run on each of the three demand scenarios.[21] The low-growth simulation shows supply exceeding demand by 2 percent overall by the end of the next decade. (See text table 3-15.) Under this scenario, the difference in supply and demand is largest for the physical sciences and least for mathematics and computer science, with engineering showing an excess supply of 2 percent.

The mid-growth scenario shows overall demand slightly exceeding supply by the year 2005. The magnitude of the excess demand is low, however, at 4 percent. Furthermore, much of the differential is attributable to large employment gains projected in the past 3 years of the forecast. Until 2002, the S&E labor market appears to be in approximate balance.

[21]The S&E supply model used to produce these estimates was developed for NSF by Dr. Robert C. Dauffenbach (the University of Oklahoma). The current model builds upon earlier research of Robert Dauffenbach and Jack Fiorito (1983).

Text table 3-15.
Estimated demand/supply differentials for scientists and engineers under alternative scenarios: 2005

	Scenarios		
	Low	Mid	High
	Percent		
Total scientists/ engineers	–2	4	10
Computer/math specialists	1	7	14
Engineers	–2	4	10
Life scientists	–5	–1	4
Physical scientists	–6	–2	3
Social scientists	–2	2	8

SOURCE: R.C. Dauffenbach, the University of Oklahoma, unpublished tabulations.

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The high-growth scenario, as noted, yields a 62-percent growth in overall employment demand for scientists and engineers from 1994 to 2005. Such a large expansion of S&E employment could result in excess demand in some fields. Overall, these differentials could reach a demand 10 percent in excess of supply. For mathematics and computer science, the differential would be near the 14-percent mark. For the physical sciences, excess demand would be approximately 3 percent. In 2000, the overall differential is about 4 percent. Thus, the high-growth aspects of the forecasted supply/demand differentials, that is, above the 5-percent level, occur in the distant years of the forecasts. If the high-growth scenario materialized, there should be sufficient time for the labor market for scientists and engineers to respond to the new higher demands.

Supply Flexibility

The supply system has historically exhibited a fairly high degree of flexibility. However, it is not infinitely responsive, and unforeseen shocks could cause dislocations beyond those found in the likely range of scenarios discussed above. Other factors limit its flexibility as well:

- The adjustment mechanisms the supply system incorporates are not without costs in lost productivity; retraining expenses; and employer, industry, and occupational mobility.
- In the high-growth scenario, it may prove difficult for higher education to respond to the demand for degrees in fields experiencing relatively high supply/demand differentials.

As costly as such dislocations are, the supply system appears capable of adjusting to rather wide differentials in demand growth. The overall demand growth differential between the low and high scenarios is 30 percentage points (62-percent growth in the high-growth scenarios versus 32-percent growth in the low-growth scenario).

Supply system operations reduce this differential to about one-third its former size: 10-percent excess demand to 2-percent excess supply, or a 12-percentage-point differential. (That is, about 60 percent of the difference in demand between the high- and low-growth scenarios can be accommodated by adjustments in the supply system.)

None of these numbers represents a high degree of disequilibrium in the market for scientists and engineers. These demand scenarios and attendant supply processes can thus be said to exhibit relative balance for S&E labor markets to the year 2005. Since the differentials that develop in the high-growth scenario occur late in the forecast, there is ample response time if the future unfolds in this manner. Of course, spot differentials in certain S&E fields are possible.

Immigrant Scientists and Engineers

Science has always been an international activity—with researchers and students seeking the best places to learn and to do their research—and immigrant scientists and engineers have always been an important part of U.S. science. The importance of this international movement has not diminished.

As of 1993, 23.0 percent of S&E doctorate holders under age 76 and residing in the United States were foreign born.[22] (See figure 3-12.) Slightly more than half of these (53 percent) have U.S. citizenship. The percentage of the foreign-born individuals among Ph.D. fields ranges from 40.3 percent in engineering to 13.1 percent in the social sciences.

Foreign-born scientists and engineers account for a larger proportion (27.8 percent) of Ph.D. scientists engaged in research and development as a primary or secondary activity (NSF, 1995). By field, this ranges from 15.9 percent in the social sciences to 43.4 percent in engineering, and is greater than the representation of foreign born individuals among the Ph.D. population for each broad Ph.D. field.

Although a majority of foreign-born Ph.D. level scientists and engineers in the U.S. received their training from U.S. institutions, 34.1 percent received their degrees outside the United States. (See figure 3-12.) This percentage varied by field, from 11.8 percent for the social sciences to 48.6 percent for the life sciences. This migration of foreign-educated talent is large and undoubtedly aids the international dissemination of ideas. Overall, in 1993, 7.8 percent of all Ph.D. scientists and engineers in the United States had received their doctorates from foreign schools. (See appendix table 3-12.)

A distribution of foreign-born S&E doctorates resident in the United States demonstrates that S&E immigration is not a new phenomenon. (See figure 3-13.) Note that this statistic is not the same as a record of S&E admissions into the United States—such a record, by education level, does not exist. Also, the count of doctoral S&E immigration from earlier years may no doubt be reduced by both human mortality and, more important, emigration. The median year of entry for 1993 foreign-born doctoral S&E was during 1970–74.[23]

Information on the number of scientists and engineers, by occupation, receiving permanent resident visas is available from the Immigration and Naturalization Service (INS).[24] The INS determines an immigrant's occupation differently for occupation- and non-occupation-based admissions.[25] For those admitted under an occupational preference, the occupation recorded is the job the immigrant will be taking in the United States. For all other immigrants, occupation is recorded as the occupation held in the last country of residence. An additional limitation of the INS data is that there is no information on degree level. It seems likely that the vast majority of individuals listing S&E occupations are not doctorate-level scientists.[26]

During the 1980s, immigration of scientists and engineers was fairly stable, increasing slightly each year. However, in 1992, there was a large jump in admissions of scientists and engineers totaling 22,870, or a 62-percent increase over immigration in 1991. (See appendix table 3-15.) The cause of this large increase is clearly related in part to the changes in the immigration law enacted in 1990. The Immigration Act of 1990 permitted large increases in employment-based quotas for highly skilled workers.

Despite an overall decline in immigration to the United States in 1993, the admission of scientists and engineers continued to rise. According to INS data, 23,534 scientists and engineers were admitted to the United States on permanent visas in 1993, representing a 3.1-percent increase over 1992. The total immigration to the United States in 1993 is estimated at 904,292; scientists and engineers constituted 2.6 percent of this total.

Engineers made up 61.6 percent of the total S&E permanent visas in 1993. Mathematical scientists and computer specialists accounted for nearly half of the remaining S&E permanent visas (SRS, forthcoming [b]).

[22]These data come from the NSF's 1993 National Survey of College Graduates (NSCG). The NSCG is a large sample of people with a bachelor's degree or higher at the time of the 1990 U.S. Census, reinterviewed in 1993. Although the sample size of Ph.D.s (10,000) is far smaller than on the SDR, it has an advantage over the SDR in capturing information on Ph.D.s from foreign institutions. The NSCG, however, does not include anyone in the United States who did not answer a Census form in 1990, and thus does not include the most recent immigrants.

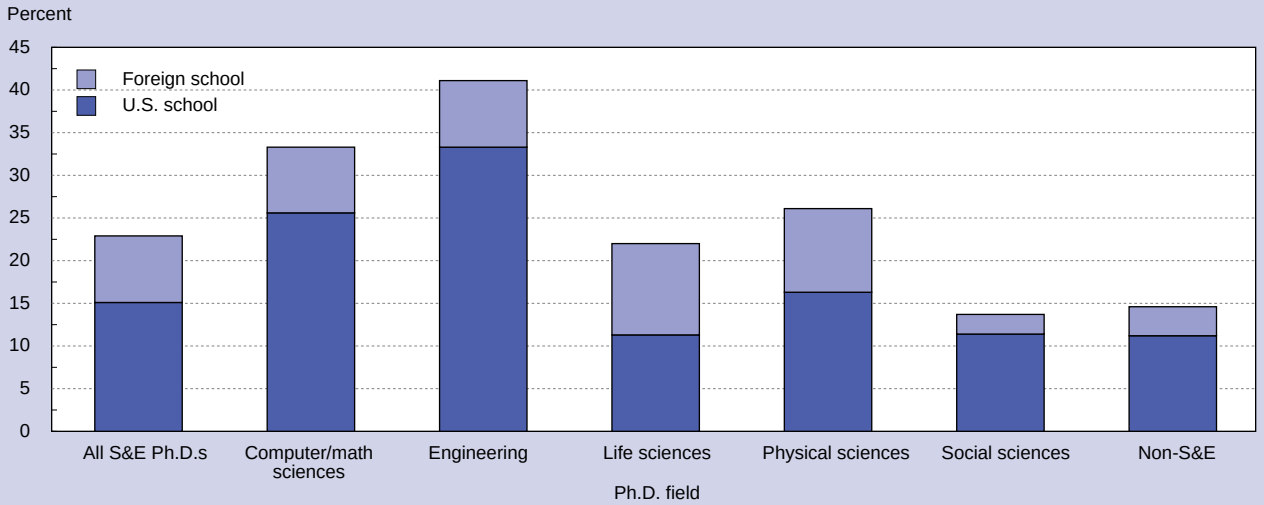
[23]Information on year of entry is reported on the NSCG for aggregate periods, so the exact median year of entry can not be calculated.

[24]This information is available in special tabulations done by NSF and published in a series of reports: *Immigrant Scientists, Engineers, and Technicians: 1991–1992* (SRS, 1995a).

[25]Until 1992, most scientists and engineers, as well as most immigrants to the United States of any occupation, entered using visa preferences for family members. Even after the increase in the availability of occupational visas, effective in 1992, only around half of scientists and engineers enter through occupational preferences.

[26]By way of comparison with another data set identifying scientists and engineers only by occupation, on the 1990 U.S. Census only 5 percent of scientists and engineers reported having doctorates, and one-third reported having less than a bachelor's degree.

Figure 3-12.
Percent of 1993 U.S. resident Ph.D.s that are foreign born



See appendix table 3-14.

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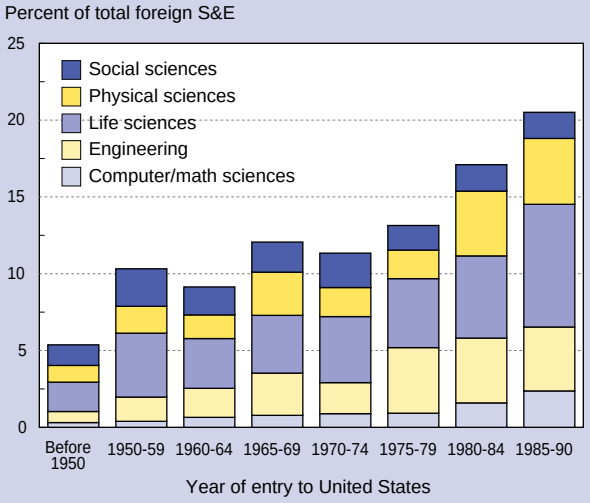
Women represented 21.3 percent of scientists and engineers admitted to the United States with permanent resident status in 1993, with 5,020 female scientists and engineers admitted. INS data for 1989 to 1993 show that the number, as well as the proportion, of female scientists and engineers immigrating to the United States has consistently increased over time. (See figure 3-14 and appendix table 3-15.)

Observation of the age distribution for persons admitted in 1993 indicates that about 58 percent of immigrant scientists and engineers were between 30 and 44 years old, nearly 28 percent were younger than 30 years old, and about 13 percent were 45 years old or older. This age distribution has held fairly constant for the past several years.

Data for 1993 show that most scientists and engineers admitted to the United States as permanent residents

Figure 3-13.
Foreign born scientists and engineers, by year of entry: 1993



SOURCE: Science Resources Studies Division, National Science Foundation, *1993 National Survey of College Graduates,* unpublished tabulations.

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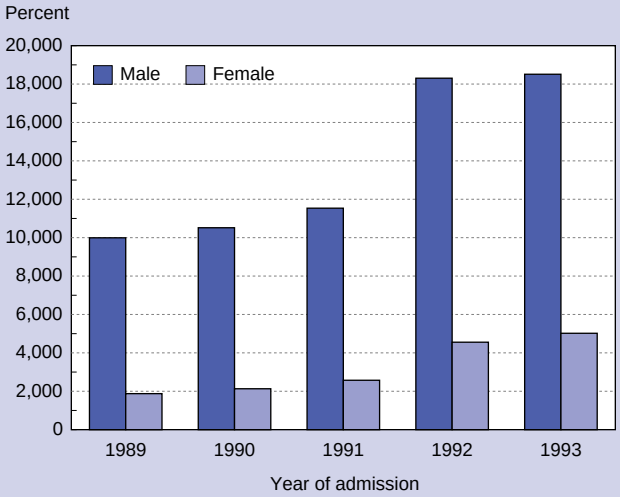
Figure 3-14.
Scientists and engineers admitted to the United States on permanent visas, by fiscal year of admission and sex



See appendix table 3-15.

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identify their country of birth as being in the Far East (SRS, forthcoming [b]). In 1993, 57.9 percent of all scientists and engineers admitted were from the Far East. India was reported as country of birth for 17.5 percent of all S&E immigrants, and China was reported by another 20.4 percent of those admitted. Immigration from these two countries combined to account for 37.9 percent of all S&E immigration, which is an increase from 1992, when 29.2 percent of all S&E immigrants reported either India or China as their country of birth. Observation of INS data for previous years shows that immigrants from the Far East have constituted a large and growing proportion of all S&E immigration.

Prior to 1991, the majority of S&E immigration was new arrivals; only a few scientists and engineers already in the United States had resident status adjusted from temporary to permanent. Data for 1991 showed proportions of both new arrivals and adjustment-of-status cases to be roughly equal, while 1992 adjustment-of-status cases increased to 65 percent of S&E immigration in that year. (See appendix table 3-15.) This trend has continued in 1993, with 68.5 percent of all S&E immigration resulting from adjustment-of-status cases.

In the wake of the 1989 Tienamen Square incident, Congress enacted the Chinese Student Protection Act of 1992, permitting Chinese nationals temporarily residing in the United States to adjust to permanent resident status. Under the provisions of the Act, 1,403 scientists and engineers were admitted in 1993. Also admitted under the Act were 654 technologists and technicians. Further adjustment-of-status cases resulting from this Act will be reflected in 1994 immigration because not all applications were submitted and processed in 1993.

Science and Engineering Workforce Issues in an International Perspective

A country's employment of scientists and engineers is a significant indicator of its level of effort in, and relative national priority for, science and technology. Thus, comparative data highlight the relative standing of the United States vis-à-vis other potential partners and competitors in the emerging global economy. Comparative data also enhance understanding of the U.S. role as an important supplier of advanced S&E training for the world's S&E workforce. Changes in this role can have significant effects on U.S. graduate education as well as on labor market conditions for scientists and engineers within the United States.

International comparisons of S&E personnel are more complicated and considerably less developed than R&D expenditure data because of differences in countries' definitions of specific jobs and methods of data collection and estimation. This section compares the proportion of S&E workforces in a limited number of industrialized countries in terms of characteristics such as the S&E proportion of the total labor force and the distributions of scientists and engineers by gender and sector.

Science and Engineering Employment as a Proportion of the Labor Force

More nonacademic scientists and engineers—3.5 million—are employed in the United States than in any other major industrialized country.[27] (See appendix table 3-16.) Japan ranks a distant second with 2.3 million nonacademic scientists and engineers. Until recently, the United States also had the highest proportion of its labor force employed as scientists or engineers—328 per 10,000 workers in 1986 (SRS, 1991). More recent data, however, show the U.S. ratio at 298, below the ratio for Sweden (522), Japan (380), and the United Kingdom (328).

Employment of Women

The United States has had more success than other industrialized countries in attracting women into the nonacademic S&E workforce. It has the highest proportion of female scientists in the labor force (54 per 10,000 workers). (See appendix table 3-16.) Canada ranks second with 48, followed by Sweden (43), France (36), and the United Kingdom (32). Among these countries, the United States has the second highest proportion of female engineers (13 per 10,000 workers); Sweden has a higher ratio of female engineers (16). Although women are vastly underrepresented in engineering in all industrialized nations, their numbers have been increasing. For example, in the United States, the ratio of female engineers per 10,000 workers rose from 8 in 1986 to 13 in 1992. In Japan, it rose from 3 in 1985 to 8 in 1990.

Employment by Sector

In five of the seven major industrialized countries, the services sector is the leading employer of scientists. Germany[28] and the United Kingdom are the exceptions—in both countries, the manufacturing sector employs the largest number of such scientists. (See appendix table 3-17.) The manufacturing sector is the second largest employer of scientists in the other five countries. In the United States, the government sector employs the third highest number of nonacademic scientists.

The manufacturing sector was the largest employer of nonacademic engineers in six of the seven countries compared. The proportions ranged from approximately 31 percent in Canada to nearly half in Sweden, the United Kingdom, and the United States. In Japan, however, more engineers are employed in the services sector than in manufacturing.

Across all countries, engineers considerably outnumber scientists in manufacturing. By occupation, industrial/mechanical engineers constituted at least half of the S&E manufacturing workforce in the United States,

[27]These data are not available on an annual basis. They represent the most recent data available from individual countries. The tabulations reported above are provided by the Center for International Studies, U.S. Census Bureau, for NSF.

[28]German data in this section are for the former West Germany only.

the United Kingdom, and Sweden. (See appendix table 3-18.) The proportion of these engineers was also high in France, Germany, and Canada, where they accounted for between 41 and 43 percent of all scientists and engineers employed in manufacturing.

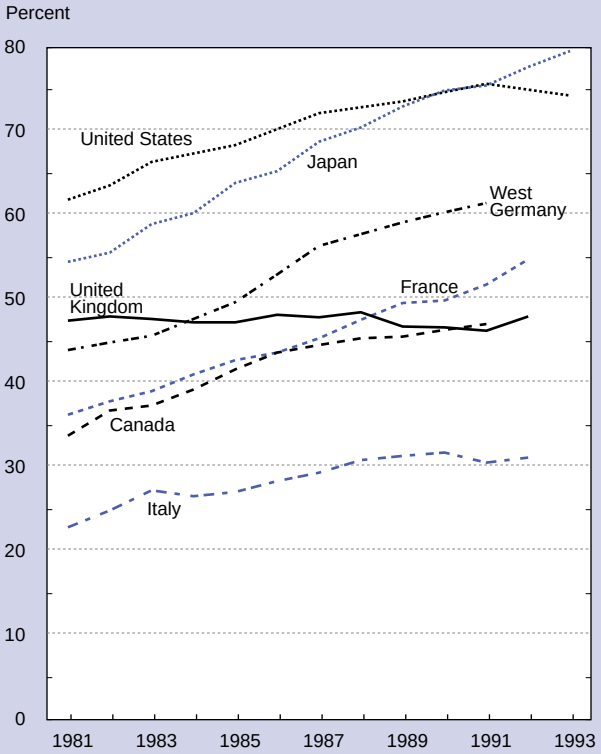
The distribution of the Japanese S&E manufacturing workforce differs from that of the other countries. In Japan, the largest proportion of its S&E manufacturing workforce was civil engineers (32 percent). (For all other countries except Germany, civil engineers accounted for less than 5 percent of the manufacturing S&E workforce.) Japan had the smallest proportion of natural scientists (4 percent) employed in manufacturing.

Research and Development Employment

Updated trend information is available from 1981 to the early 1990s on scientists and engineers involved in R&D in the labor forces of the "Big 7" industrialized countries. From 1981 to 1993, the U.S. percentage of total R&D scientists and engineers among the seven countries declined slightly, and Japan edged the United States out of its long-term lead in terms of the number of scientists and engineers in R&D per 10,000 in the labor force. (See figure 3-15 and appendix table 3-19.)

Great disparities exist in the distributions of scientists and engineers engaged in R&D between the advanced industrialized nations, the newly industrializing countries, and the developing economies of the world. (See figure 3-16.) Although the data for countries that are not part of the Organisation for Economic Co-operation and Development are subject to interpretation, the big picture is quite clear—there is a strong correlation between level of industrialization and development and the presence of S&E expertise in the labor force. With continued development, demand for S&E personnel should continue, whether from in-country or foreign sources.

Figure 3-15.
Scientists and engineers engaged in R&D per 10,000 labor force, by country



See appendix table 3-19.

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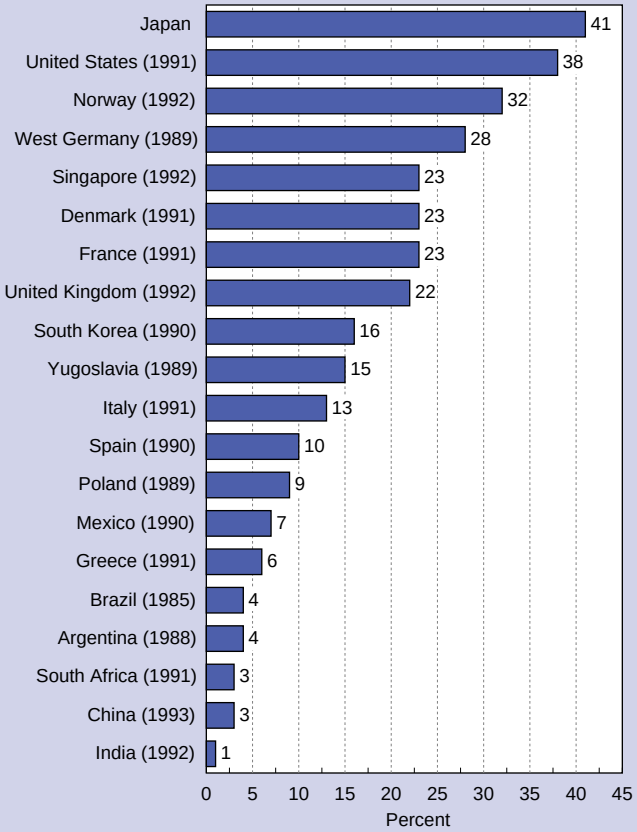
Figure 3-16.
Scientists and engineers engaged in R&D per 10,000 population



SOURCE: Science Resources Studies Division, National Science Foundation, International Science & Technology Data Update: 1995, (forthcoming).

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References

Collins, E.L. 1988. "Meeting the Scientific and Technical Staffing Requirements of the American Economy." In *Science and Public Policy*, October 1988, pp. 335–342.

Committee on Science, Engineering, and Public Policy. 1995. *Reshaping the Graduate Education of Scientists and Engineers*. Washington, DC: National Academy Press.

Dauffenbach, R.C. 1990. *Quality and Qualifications in the Market for Scientists and Engineers*. Stillwater, OK: Oklahoma State University.

Dauffenbach, R.C., and J. Fiorito. 1983. *Projections of Supply of Scientists and Engineers to Meet Defense and Nondefense Requirements, 1981–87*. Contractor Report to the National Science Foundation. Stillwater, OK: Oklahoma State University.

Leslie, L.L., and R.L. Oaxaca. 1991. *Scientist and Engineer Supply and Demand*. Tucson, AZ: University of Arizona.

National Science Board (NSB). 1989. *Science and Engineering Indicators: 1989*. NSF 89-1. Washington, DC: GPO.

Science Resources Studies Division (SRS), National Science Foundation. 1990. *Science and Engineering Personnel: A National Overview*. NSF 90-310. Washington, DC: NSF.

———. 1991. *International Science and Technology Data Update*. NSF 91-309. Washington, DC: NSF.

———. 1995a. *Immigrant Scientists, Engineers, and Technicians: 1991–92*. SRS detailed tables. NSF 95-310. Arlington, VA: NSF.

———. 1995b. *Nonacademic Scientists and Engineers: Trends from the 1980 and 1990 Censuses*. NSF 95-306. Arlington, VA: NSF.

———. Forthcoming (a). *Characteristics of Recent Science and Engineering Graduates: 1993*. SRS detailed tables. Arlington, VA: NSF.

———. Forthcoming (b). *Immigrant Scientists, Engineers, and Technicians: 1993*. Arlington, VA: NSF.

———. Forthcoming (c). *Scientists, Engineers, and Technicians in Nonmanufacturing Industries: 1993*. SRS detailed tables. Arlington, VA: NSF.

Stephan, P., and S. Levin. 1992. *Striking the Mother Lode in Science: The Importance of Age, Place, and Time*. New York: Oxford University Press.

U.S. Bureau of Labor Statistics (BLS), Department of Labor. 1994. *Bureau of Labor Statistics' National Industry-Occupation Employment Matrix 1983–1993 Time Series*. Washington, D.C.

———. 1995. *Employment and Earnings* 42, no. 1 (January). Washington, DC.