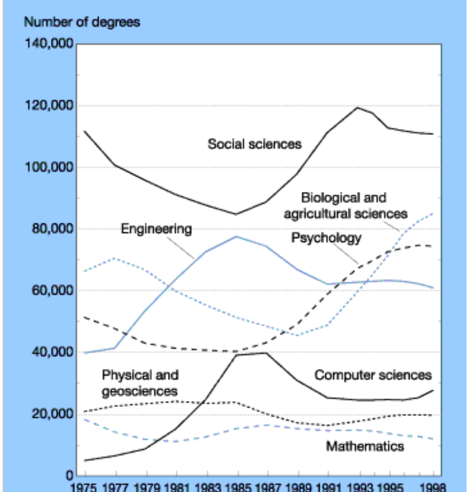
A snapshot of science and science education in the United States

K-12 science education

Control of K-12 education is the responsibility of the individual state governments; there is no national curriculum. Individual states (and, in some cases, even the larger cities) define their own curricula, their own required content, and their own standards of assessment. Local authorities, relying principally on local funding, run the schools. Each school district (and there are more than 15,000) has its own curriculum committee, usually, but not always, adopting its own state's mandated standards of learning. All states now have science content standards for grades K-12. These standards are very loosely based on a set of National Science Education Standards (NSES) developed by the National Research Council.

Two of the biggest problems facing science education are the quality and quantity of teachers. Older, well-qualified teachers are reaching retirement age. Newer teachers are likely to have an inadequate background in chemistry, and those who are qualified often stop teaching after only a few years. There also is the problem of teachers of chemistry who are actually biology teachers teaching out of field. Teacher salaries are very dependent on location; while an experienced teacher might be paid quite well in some parts of the country, this is not true for new teachers or for most parts of the country. Teaching does not have a high enough status to attract and retain the brightest and the best science students, who are steered into careers in research.

Figure 2-11.
Bachelor's degrees earned in selected S&E fields: 1975–98



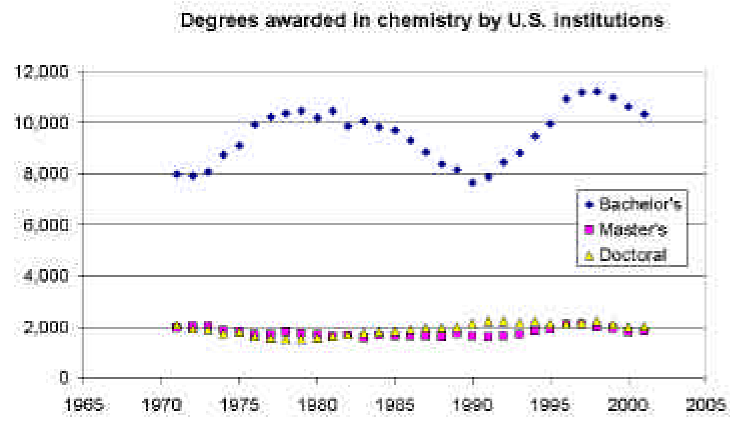
NOTE: Geosciences include earth, atmospheric, and ocean sciences.
See appendix table 2-16. *Science & Engineering Indicators – 2002*

Chemistry education. Although science is a significant component of student's education from the time they enter school, students do not experience a chemistry course until they reach high school. Chemistry is taught as a one-year, elective course in U.S. high schools to about 54 percent of students. This number has risen steadily since the late 1970s, when around 30 percent of students opted to take high school chemistry. The higher percentage is in response to a general increase in state science course requirements for a high school diploma. Most frequently, this course is introduced in the 10th or 11th grades (15- and16-year-old students). The traditional first-year chemistry course tends to focus on inorganic and physical chemistry, and may include little practical work. Newer courses, following the National Science Education Standards developed under the aegis of the National Research Council, provide a broader introduction to chemistry and promote all sciences for all students at every grade level. (However, in the United States, each state has developed its own standards, which teachers are expected to follow.)

A second-year chemistry course is taken by a much smaller group of students. This course is likely to be considered preparatory to, or even equivalent to, an undergraduate General Chemistry course. Some students take an Advanced Placement (AP) course while in high school, and if they complete this successfully, they may test-out of the first-year university course. The AP course is currently under a great deal of criticism.

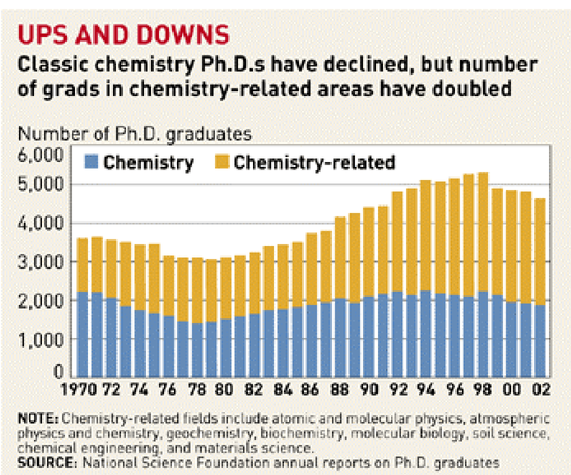
Undergraduate education

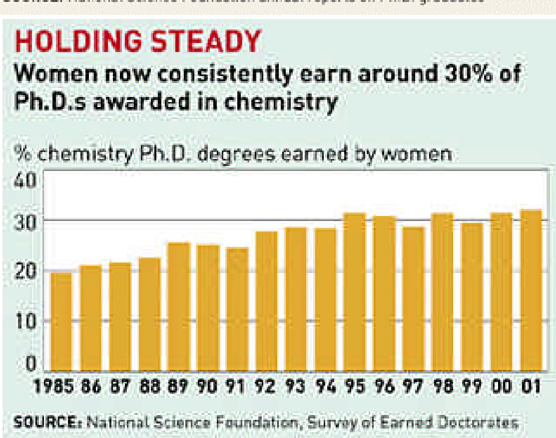
Students enter colleges and universities after 12 years of elementary and secondary education. Key challenges for undergraduate education in science and engineering (S&E) include preparing teachers for K–12 and college levels, preparing scientists and engineers to fill needed workforce requirements and provide the capacity for long-term innovation, providing understanding of basic science and mathematics concepts for all students, and measuring what students learn. These challenges relate to the nation's ability to retain its innovation capacity and international position in science and technology (S&T).



Expectations for college attendance have increased dramatically over the past 20 years, even among low-performing students. Overall, 63% of high school graduates enroll in college immediately after completion of their degree. High-school graduates from low-income families enter four-year institutions at lower rates than those from high-income families.

The number of overall S&E bachelor's degrees increased in the past two decades and leveled off in the late 1990s. Although approximately 25–30 percent of students entering college in the United States intend to major in S&E fields, a considerable gap exists between freshman intentions and successful completion of S&E degrees. A study of first-year S&E students in 1990 found that fewer than 50 percent had completed an S&E degree within five years. Underrepresented minorities complete S&E programs at a lower rate than other groups.



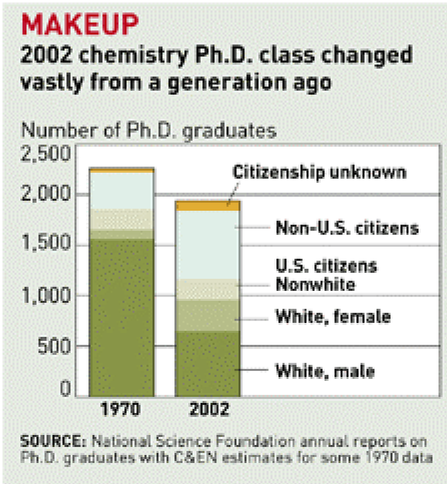


Graduate education

Declining S&E degree trends at the master's level resemble those at the bachelor's level. After a steady upward trend during the past two decades, the overall number of earned doctoral degrees in S&E fields declined in 1999.

Each year from 1986 to 1996, the number of foreign students earning S&E doctoral degrees from universities in the United States increased; it declined every year thereafter. During the period 1986–99, foreign students earned 120,000 doctoral degrees in S&E fields. Two recent surveys found that at least half of all U.S. universities have seen graduate-student applications from overseas drop since Fall 2003. The statistics show a precipitous decline in students from India and China, which supply nearly one-third of all U.S. graduate students. Government and university officials disagree over whether the visa-application system is to blame for the decline, especially for students in mathematics, science, and engineering.

The National Institutes of Health (NIH) and the National Science Foundation support most of the S&E graduate

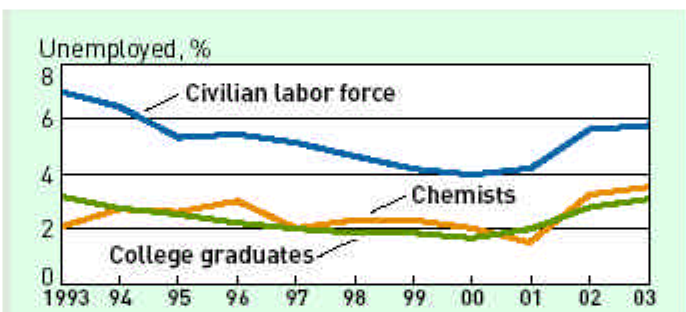


students whose primary support comes from the Federal Government, 17,000 and 14,000 students, respectively.

By 1999, more than 72 percent of foreign students who earned S&E doctoral degrees at universities in the United States reported that they planned to stay in the United States after graduation, and 50 percent accepted firm offers to do so. These percentages in the late 1990s represent significant increases. Historically, approximately 50 percent of foreign doctoral recipients planned to stay in the United States after graduation, and a smaller proportion had firm offers to do so. Although the number of foreign doctoral recipients planning to stay in the United States increased in the 1990s, opportunities are expanding for returning to their home countries or for collaborative research and networking with home-country scientists.

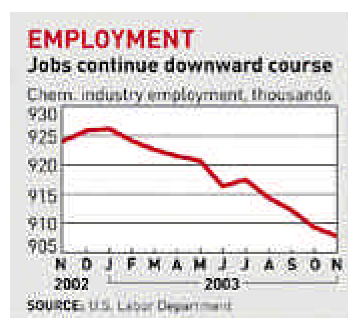
The need for reform of doctoral education has been widely noted and discussed. In 1995, the Committee on Science, Engineering, and Public Policy (COSEPUP) recommended broadening the education of doctoral students beyond research training. Because more than one-half of all doctoral recipients obtain nonacademic employment, COSEPUP recommended that doctoral students acquire an education in the broad fundamentals of their field, familiarity with several subfields, the ability to communicate complex ideas to nonspecialists, and the ability to work well in teams.

Science and engineering workforce



The U.S. workforce in 1999 included 11 million college-educated individuals with either science and engineering (S&E) degrees or S&E occupations. The vast majority (10.5 million) held at least one college degree in a science or engineering field.

Since 1980, nonacademic S&E jobs grew at more than four times the rate of the U.S. labor force as a whole. Nonacademic S&E jobs increased by 159 percent between 1980 and 2000—an average annual growth rate of 4.9 percent compared with 1.1 percent for the entire labor force.



The total number of retirements among S&E-degreed workers will increase dramatically over the next 20 years, barring large changes in retirement rates. More than half of S&E-degreed workers are age 40 or older, and the 40-44 age-group is nearly four times as large as the 60-64 age group. However, the rate of S&E-degreed workers reaching retirement ages will remain less than the rate of S&E degree production for many years.

Research and development

US industry funds roughly two-thirds, and the federal government, one-third, of an approximately US$300 billion/year R&D enterprise. In the past fifteen years, US federal R&D spending has remained stable as a share of the discretionary budget, but has declined as a share of the total federal budget and as a share of the

US economy. In contrast, industry-funded R&D has increased, although most of this funding is in the applied research and development areas.

Industry performed the largest share of the nation's R&D—75 percent. Universities and colleges performed 11 percent, and the Federal Government performed 7 percent. Federally Funded Research and Development Centers, which are administered by various industrial, academic, and nonprofit institutions, accounted for an additional 4 percent, and other nonprofit organizations accounted for 3 percent.

R&D spending by U.S. affiliates of foreign companies in 1997–98 was $22 billion. Chemical and computer and electronic product manufacturing had the largest single-industry shares of foreign R&D spending in the United States in 1998 (33 and 20 percent, respectively). They include the largest subsectors attracting foreign R&D funding: pharmaceuticals and communications equipment. More than one-half of the chemicals and pharmaceuticals R&D performed by foreign-owned subsidiaries in the United States is performed by Swiss and German units.

Of the $15 billion spent abroad in R&D by the nation's majority-owned foreign affiliates in 1998, more than two-thirds took place in five countries: Canada, France, Germany, Japan, and the United Kingdom. R&D performed in chemicals and pharmaceuticals overseas reached $4 billion in 1998; nearly $1 billion was located in the United Kingdom.

SOURCES OF ACADEMIC R&D FUNDS

Federal share continued long-term trend of just under 60% of total

												ANNUAL CHANGE	
$ MILLIONS	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2000–01	1991–2001
Federal govt.	$10,234	$11,093	$11,957	$12,646	$13,328	$13,836	$14,309	$15,145	$16,071	$17,508	$19,191	9.6%	6.5%
Institutional funds	3,367	3,547	3,589	3,827	4,047	4,170	4,697	5,002	5,395	5,933	6,553	10.5	6.9
State & local govt.	1,474	1,491	1,559	1,554	1,689	1,811	1,909	1,944	2,019	2,196	2,315	5.4	4.6
Industry	1,204	1,279	1,360	1,422	1,489	1,605	1,737	1,888	2,028	2,152	2,234	3.8	6.4
All other sources	1,307	1,409	1,486	1,574	1,613	1,618	1,711	1,869	1,992	2,253	2,430	7.9	6.4
TOTAL	$17,586	$18,819	$19,951	$21,023	$22,166	$23,040	$24,363	$25,848	$27,505	$30,042	$32,723	8.9%	6.4%

NOTE: Institutional fiscal years. SOURCE: National Science Foundation, 2003, "Academic Research and Development Expenditures: Fiscal Year 2001"

FIELDS OF ACADEMIC R&D SPENDING

More than one-third of investment in the physical sciences went to chemistry

												ANNUAL CHANGE	
$ MILLIONS	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2000–01	1991–2001
ALL SCIENCES	$14,679	$15,755	$16,795	$17,668	$18,650	$19,332	$20,523	$21,778	$23,245	$25,494	$27,723	8.7%	6.6%
Life	9,472	10,196	10,851	11,466	12,186	12,713	13,588	14,593	15,610	17,460	19,189	9.9	7.3
Physical	1,939	2,055	2,130	2,177	2,255	2,257	2,370	2,482	2,604	2,708	2,800	3.4	3.7
Physics	881	921	940	957	989	987	1,058	1,078	1,149	1,206	1,237	2.6	3.5
Chemistry	671	705	740	759	771	801	820	876	918	960	1,007	4.9	4.1
Psychology & social	1,033	1,144	1,246	1,312	1,389	1,478	1,521	1,575	1,715	1,813	2,017	11.3	6.9
Environmental	1,119	1,242	1,319	1,396	1,433	1,488	1,532	1,624	1,691	1,763	1,827	3.6	5.0
Computer	554	555	608	646	682	690	709	746	861	875	954	9.0	5.6
Mathematical	230	248	272	282	279	288	289	310	313	341	357	4.7	4.5
Other	332	315	369	389	426	418	514	448	451	534	579	8.4	5.7
ALL ENGINEERING	$2,907	$3,062	$3,156	$3,355	$3,515	$3,707	$3,839	$4,069	$4,260	$4,547	$5,000	10.0%	5.6%
Chemical	244	261	274	279	297	317	317	327	349	375	414	10.4	5.4
TOTAL	$17,586	$18,817	$19,951	$21,023	$22,165	$23,039	$24,362	$25,847	$27,505	$30,041	$32,723	8.9%	6.4%

NOTE: Institutional fiscal years.
SOURCES: National Science Foundation, 2003, "Academic Research and Development Expenditures: Fiscal Year 2001"; WebCASPAR Database System

Key science policy issues

In the aftermath of 11 September 2001, security issues have become paramount. The government has increased its funding of Defense R&D and counter-terrorism R&D, particularly bio-terrorism. Congress has also approved a new Department of Homeland Security whose primary mission is to protect the US from terrorism. The emphasis on national security has affected the free movement of people, including foreign students and visiting scientists, and information, particularly the output of scientific journals. US policy-makers are engaged in a dialogue with the academic and scientific communities on how to balance needs of national security with scientific openness. There is not yet a consensus on this issue.

Sources

National Science Board, *Science and Engineering Indicators 2002*
Chemical & Engineering News
American Chemical Society.