

SECTORAL COMPOSITION OF R&D PERFORMANCE

Since the early 1980s, R&D performance in some sectors has grown much faster than in others. The industrial sector in particular has grown increasingly dominant (figure 1). In 1980, industry performed 68.4 percent of the nation's R&D, the academic sector performed 10.2 percent, laboratories within Federal agencies (Federal intramural R&D) performed 12.4 percent, and the nonprofit sector performed 2.6 percent. All FFRDCs combined performed 6.4 percent of the nation's R&D. Industry's defense-related R&D efforts accelerated in the early 1980s, and its share of R&D performance rose to 71.8 percent in 1985.

From 1985 to 1994, R&D performance grew by only 1.4 percent per year in real terms for all sectors combined. This growth was not evenly balanced across performing sectors, however. R&D performance at universities and colleges grew by 5.4 percent per year in real terms, compared with only 1.0 percent for industry, -0.5 percent for Federal intramural performance, 5.0 percent for nonprofit organizations, and 0.3 percent for all FFRDCs combined.

These growth rates changed dramatically from 1994 to 2000. Total R&D performance in real terms averaged 5.8 percent growth per year, which was substantially higher than in the earlier sluggish period. Yet, R&D performance at universities and colleges grew at a slower rate of 4.1 percent per year in real terms.¹⁵ Industrial R&D expanded at a rate of 7.1 percent in real terms (despite a decline in company-reported Federal financing of R&D). Federal intramural performance decreased by 0.3 percent per year in real terms. Nonprofit organizations, according to current estimates, increased their R&D performance by 7.1 percent per year in real terms over the same 6-year period. Finally, R&D performance at all FFRDCs experienced essentially no change in real terms over this period.

Industry is projected to have performed 68.3 percent of the nation's total R&D in 2003 (table 1). The estimated

¹⁵Recent methodological improvements in the estimation of total academic R&D have resulted in a break in the time series. Data for years before 1998 are slightly overstated compared with the data for later years. Had the same methodology been used for all years in the series, the average annual growth rate would have been closer to 4.3 percent per year in real terms from 1994 to 2000. See sidebar, "Academic Passed-Through Funds."

\$193.7 billion in industrial R&D performance represents a 2.2 percent average annual decrease in real terms from the 2000 level. Universities and colleges are projected to have performed 14.2 percent (\$40.3 billion) of national R&D in 2003, representing an average annual increase of 7.9 percent in real terms over their R&D in 2000. The Federal Government is projected to have performed 8.8 percent (\$25.0 billion) of U.S. R&D in 2003, an average annual increase in real terms of 9.9 percent over the 2000–2003 period. All FFRDCs combined performed a projected \$12.2 billion of R&D in 2003, or 4.3 percent of the U.S. total. The nonprofit sector performed a projected \$12.7 billion in 2003, or 4.5 percent of the U.S. total.

INDUSTRIAL R&D BY INDUSTRY, FIRM SIZE, AND R&D INTENSITY

As previously described, R&D performed by private industry reached a projected \$193.7 billion in 2003 (table 1). This total represents a 2.2 percent average annual decline in real terms from the 2000 level of \$197.5 billion. Most of this decline was in industry-financed R&D. Companies funded 91.1 percent (\$176.4 billion) of their 2003 R&D performance, with the Federal Government funding nearly all the rest (\$17.3 billion, or 8.9 percent, of the total). The federally funded share of industry's R&D performance total has fallen considerably from its most recent peak of 31.9 percent in 1987. For more than a decade the largest component of R&D in the United States has been performed by private industry through private industry's own funds. This component of U.S. R&D grew from 43 percent of total U.S. R&D in 1953 to a projected 62 percent in 2003.

R&D IN NONMANUFACTURING INDUSTRIES

Until the 1980s, little attention was paid to R&D performed by nonmanufacturing companies largely because R&D activity in this sector was relatively small compared with the R&D operations of manufacturing companies. Before 1983, nonmanufacturing industries accounted for less than 5 percent of total industrial R&D performance (including industry-administered FFRDCs), but by 2001 (the most current year for detailed data on

Academic Passed-Through Funds

The national R&D estimates presented in this report represent survey data that have been adjusted to eliminate double-counted funds. Only for the academic sector does surveyed R&D performance include research funds passed through or subcontracted to outside organizations. (Respondents in the other surveyed sectors are instructed to exclude R&D subcontracted to other organizations from their performance totals.) The amount of R&D funds passed through to subrecipients has grown from at least 3.8 percent of total academic R&D (\$1.0 billion) in FY 1998 to at least 5.0 percent of total academic R&D (\$1.6 billion) in FY 2001. Table 4 illustrates that a higher percentage of federally funded R&D dollars are passed through to subrecipients than non-Federal sources of funds. In FY 2001, 7.2 percent of all federally funded academic R&D was passed through to

subrecipients as contrasted to 1.8 percent of all non-Federal sources of funds. It is unclear whether this difference is the result of Federal sources of funding explicitly encouraging cross-institution R&D collaboration.

Given the coverage of the Academic R&D Survey and the specific wording of its instructions, it is reasonable to assume that virtually all of the R&D expenditures that were reported as being passed to educational subrecipients were captured by the survey twice—once from the originating institutions and once from the subrecipient institutions. Thus to make the academic R&D data more comparable to that of other sectors, R&D reported as “passed through” to educational subrecipients has been netted out of academic R&D for FY 1998 and later years in this report.

TABLE 4. Academic research and development funds passed through to subrecipients: FY 1998–2001

Source of funds	R&D expenditures (millions of dollars)				Passed-through expenditures as share of corresponding R&D total (percent)			
	1998	1999	2000	2001	1998	1999	2000	2001
Total R&D	25,848	27,505	30,042	32,723	na	na	na	na
Federal R&D	15,145	16,071	17,508	19,191	na	na	na	na
Non-Federal R&D	10,703	11,434	12,534	13,532	na	na	na	na
Funds passed through to all subrecipients								
Total R&D	994	1,253	1,426	1,627	3.8	4.6	4.7	5.0
Federal R&D	846	1,027	1,205	1,380	5.6	6.4	6.9	7.2
Non-Federal R&D	148	226	221	247	1.4	2.0	1.8	1.8
Funds passed through to educational subrecipients								
Total R&D	479	572	705	793	1.9	2.1	2.3	2.4
Federal R&D	421	502	630	707	2.8	3.1	3.6	3.7
Non-Federal R&D	58	70	74	86	0.5	0.6	0.6	0.6

na not applicable

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NOTE: Data on passed-through funds are lower bound estimates because values were not imputed for nonrespondents. In addition, some respondents reporting total and Federal funds passed through did not break out these funds by subrecipient type (educational or other).

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Research and Development Expenditures at Universities and Colleges, Fiscal Year 2001.

industrial R&D), they accounted for 39.2 percent.¹⁶ In 2001, firms classified in nonmanufacturing industries

¹⁶Beginning with the 2001 survey cycle, industry-administered FFRDCs were removed from the industrial R&D statistics. They are now separately surveyed and reported in the national statistics. This resulted in a relative increase in the share of R&D performed by nonmanufacturing industries. In 2000, when these FFRDCs were included in the industrial R&D totals, R&D performed by nonmanufacturing industries accounted for 37.8 percent of total industrial R&D.

performed \$77.8 billion of R&D (\$72.4 billion in funds provided by companies and other non-Federal sources and \$5.4 billion in Federal support) (table 5). Of this amount, 79 percent (\$56.9 billion) can be attributed to the following three groups of nonmanufacturing industries: trade, software and computer-related services,

and scientific R&D services.¹⁷ An examination of these three groups of industries helps explain the dramatic growth in nonmanufacturing R&D over the past 2 decades.

R&D performance attributed to the trade industry reached \$24.4 billion in 2001. Recent analysis of survey microdata revealed that only a fraction of this R&D was performed by companies whose primary business was wholesale or retail trade. As a consequence of assigning firms to one industry based on payroll data—the classification method used for the NSF Survey of Industrial Research and Development—some large companies were classified into an industry that was not closely related to its reported R&D activities.¹⁸ Although imperfect, this classification scheme reasonably categorizes most companies into industries closely aligned with their primary business activities. Unfortunately, because the sale and marketing of goods and services is a trade activity, a large pharmaceutical firm or electronics manufacturer would be classified in the trade industry if the payroll associated with its sales and marketing efforts outweighed that of any other industrial activity in the company. (See sidebar, “Redistributing Trade R&D” for further discussion of this issue.)

Nonmanufacturing industries associated with software and computer-related services such as data processing and systems design performed approximately \$24.0 billion of company-funded R&D in 2001.¹⁹ As computing and IT became more powerful and ubiquitous over the past 2 decades, the demand for services associated with these technologies boomed. The R&D of companies providing these services also grew dramatically during this period. In 1987, when an upper bound estimate of software and other computer-related

services R&D first became available, companies classified in the industry group “computer programming, data processing, other computer-related, engineering, architectural, and surveying services” performed \$2.4 billion of company-funded R&D, or 3.8 percent of all company-funded industrial R&D. In 2001 the company-funded R&D of a comparable group of industries (excluding engineering and architectural services) was greater by a factor of 10 and accounted for 13.2 percent of all company-funded industrial R&D²⁰ (table 6). This trend in the growth of software and computer-related services R&D shows no sign of slowing. Despite essentially no growth in total company-funded, industry-performed R&D between 2000 and 2001, the company-funded R&D for this group of industries grew by 10 percent.

The R&D performed by companies in the scientific R&D services industry more than doubled in the 4 years between 1997 and 2001 from \$7.0 to \$14.2 billion.²¹ The portion of this industry’s R&D that was company-funded increased at an even faster pace, from \$4.7 billion in 1997 to \$10.9 billion in 2001. The scientific R&D services industry comprises companies that specialize in conducting R&D for other organizations, such as many biotechnology companies. (See sidebar, “Biotechnology R&D in Industry.”) Although these companies and their R&D activities are classified as nonmanufacturing because they provide business services, many of the industries they serve are manufacturing industries. This implies that the R&D activities of a research firm that services a manufacturer would have been classified as R&D in manufacturing if the same research firm were a subsidiary of the manufacturer. Consequently, a growth in measured R&D in services may, in part, “reflect a more general pattern of industry’s increasing reliance on outsourcing and contract R&D” (Jankowski 2001).

¹⁷“Trade” refers to both the wholesale and retail trade industries and is a distinct entry in the NSF industry R&D statistics, as is scientific R&D services. Software and computer-related services, however, is the sum of three distinct industries from the NSF statistics: software, other information, and computer systems design and related services.

¹⁸Details on how companies are assigned industry codes in the NSF Survey of Industrial Research and Development can be found on the NSF website (<http://www.nsf.gov/sbe/srs/nsf02312/sectb.htm#frame>).

¹⁹Although disclosure of Federal R&D funding prohibited the precise tabulation of total R&D performance for this industry, total R&D was between \$24.5 billion and \$24.6 billion.

²⁰The introduction of a more refined industry classification scheme in 1999 allowed more detailed reporting in nonmanufacturing industries. For the cited 2001 statistic, the R&D of companies in software, other information, and computer systems design and related services industries were combined. These three industries provided the closest approximation to the broader category cited for earlier years without exceeding the coverage of the broader category.

²¹Despite the change of industry classification schemes in 1999, analysts have verified that data for the scientific R&D services industry are comparable over the period under discussion.

TABLE 5. Industrial research and development performance, by industry and source of funding: 2001

Industry	NAICS code	R&D funding (millions of dollars)			Percent of company-funded R&D
		Total	Federal Government	Company funded	
All industries	21–23, 31–33, 42, 44–81	198,505	16,899	181,606	100.0
Manufacturing	31–33	120,705	11,484	109,221	60.1
Food	311	1,819	0	1,818	1.0
Beverage and tobacco products	312	152	0	152	0.1
Textiles, apparel, and leather	313–16	D	D	255	0.1
Wood products	321	182	0	181	0.1
Paper, printing, and support activities	322, 323	D	D	2,664	1.5
Petroleum and coal products	324	D	D	1,057	0.6
Chemicals	325	17,892	180	17,713	9.8
Basic chemicals	3251	1,876	42	1,835	1.0
Resin, synthetic rubber, fibers, and filament	3252	D	D	2,745	1.5
Pharmaceuticals and medicines	3254	10,137	0	10,137	5.6
Other	325 (minus 3251–52, 3254)	D	D	2,996	1.6
Plastics and rubber products	326	D	D	2,245	1.2
Nonmetallic mineral products	327	990	11	978	0.5
Primary metals	331	485	6	479	0.3
Fabricated metal products	332	1,599	54	1,545	0.9
Machinery	333	6,404	67	6,337	3.5
Computer and electronic products	334	47,079	5,848	41,232	22.7
Computers and peripheral equipment	3341	D	D	3,165	1.7
Communications equipment	3342	15,507	298	15,209	8.4
Semiconductor and other electronic components	3344	14,358	148	14,210	7.8
Navigational, measuring, electromedical, and control instruments	3345	12,947	5,382	7,565	4.2
Other	334 (minus 3341–42, 3344–45)	D	D	1,083	0.6
Electrical equipment, appliances, and components	335	4,980	301	4,680	2.6
Transportation equipment	336	25,965	4,961	21,004	11.6
Motor vehicles, trailers, and parts	3361–63	D	D	16,089	8.9
Aerospace products and parts	3364	7,868	3,785	4,083	2.2
Other	336 (minus 3361–64)	D	D	832	0.5
Furniture and related products	337	301	0	301	0.2
Miscellaneous manufacturing	339	6,606	25	6,581	3.6
Medical equipment and supplies	3391	D	D	5,903	3.3
Other	339 (minus 3391)	D	D	678	0.4
Nonmanufacturing	21–23, 42, 44–81	77,799	5,415	72,384	39.9
Mining, extraction, and support activities	21	D	D	846	0.5
Utilities	22	133	19	114	0.1
Construction	23	320	1	320	0.2
Trade	42, 44, 45	24,372	88	24,284	13.4
Transportation and warehousing	48, 49	1,848	72	1,776	1.0
Information	51	D	D	17,259	9.5
Publishing	511	13,760	44	13,716	7.6
Newspaper, periodical, book, and database	5111	649	0	649	0.4
Software	5112	13,111	44	13,067	7.2
Broadcasting and telecommunications	513	D	D	1,270	0.7
Other	51 (minus 511, 513)	D	D	2,273	1.3
Finance, insurance, and real estate	52, 53	D	D	2,424	1.3
Professional, scientific, and technical services	54	27,704	5,065	22,640	12.5
Architectural, engineering, and related services	5413	3,386	1,021	2,365	1.3
Computer systems design and related services	5415	9,154	498	8,656	4.8
Scientific R&D services	5417	14,244	3,352	10,893	6.0
Other	54 (minus 5413, 5415, 5417)	920	194	726	0.4
Management of companies and enterprises	55	381	0	381	0.2
Health care services	621–23	1,149	29	1,120	0.6
Other	56, 61, 624, 71, 72, 81	1,259	38	1,221	0.7

D data withheld to avoid disclosing operations of individual companies; NAICS North American Industry Classification System; R&D research and development

NOTE: Manufacturing companies with fewer than 50 employees and nonmanufacturing companies with fewer than 15 employees were sampled separately without regard to industry classification to minimize year-to-year variation in survey estimates. However, estimates for companies in these groups are included with their respective NAICS classification for this table. Company funding includes all non-Federal funding.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2001.

Redistributing Trade R&D

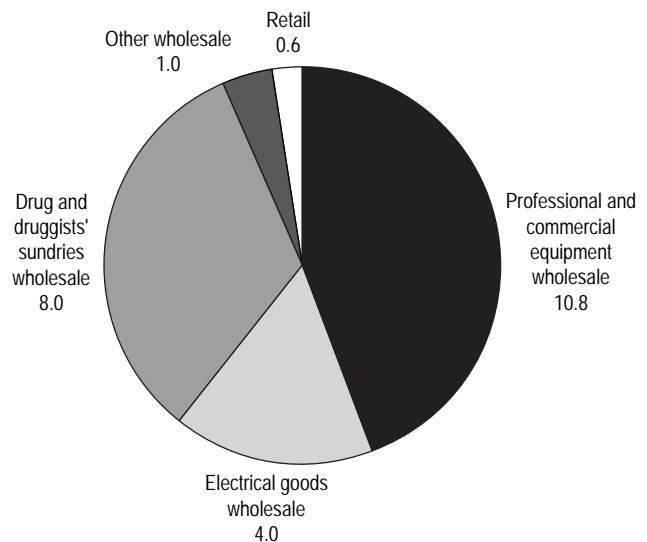
Ongoing investigations of the data underlying NSF's published R&D estimates for industry reveal that much of the R&D classified into the trade industry is an artifact of the automated industry classification methodology. Most of the R&D-performing companies with large amounts of payroll associated with retail or wholesale trade activities are in fact manufacturing firms that have integrated their supply chains and have brought their warehousing, sales, and marketing efforts in-house. Figure 13, which breaks the \$24.4 billion into more detailed industry codes, helps clarify the activities of the R&D-performing companies currently classified in trade. Most of the R&D classified into the trade industry falls into three specific wholesale trade industries:

- **Professional and commercial equipment wholesalers [North American Industry Classification System (NAICS) 4214].** This industry comprises establishments primarily engaged in wholesaling photographic equipment and supplies; office, computer, and computer peripheral equipment; and medical, dental, hospital, ophthalmic, and other commercial and professional equipment and supplies. The computer and electronic products manufacturing industry (NAICS 334) manufactures these products.
- **Electrical good wholesalers (NAICS 4216).** This industry comprises establishments primarily engaged in wholesaling electrical apparatus and equipment, electrical appliances, televisions, and radios. The electrical equipment, appliances, and components manufacturing industry (NAICS 335) manufactures these products.
- **Drugs and druggists' sundries wholesalers (NAICS 4222).** This industry comprises establishments primarily engaged in wholesaling biological and medical products; botanical drugs and herbs; and pharmaceutical products intended for

internal and external consumption in forms such as ampoules, tablets, capsules, vials, ointments, powders, solutions, and suspensions. The pharmaceuticals and medicines manufacturing industry (NAICS 3254) manufactures these products.

Using the assumption that the R&D reported in a trade industry is more closely aligned with the manufacturing of the product being sold than the trade activity itself, it is possible to redistribute almost all of the \$24.4 billion of trade R&D into manufacturing industries. Figure 14 illustrates the effect of redistributing the \$22.8 billion of R&D in the above three wholesale trade industries into their corresponding manufacturing industries. After the redistribution, the R&D within the computer and electronic products manufacturing industries exceeds all nonmanufacturing R&D combined.

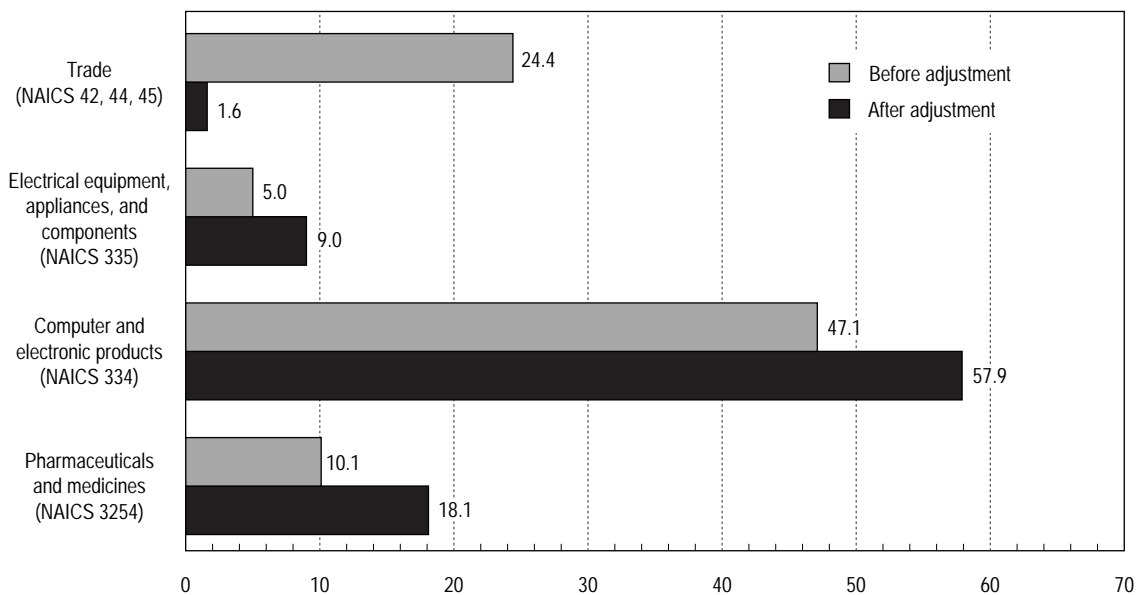
FIGURE 13. Trade industry research and development detail: 2001 (Billions of dollars)



SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2003.

Redistributing Trade R&D (Continued)

FIGURE 14. Effect of redistributing trade research and development, by impacted industry: 2001
(Billions of dollars)



NAICS North American Industry Classification System

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2003.

Although a great deal of R&D in the United States is related in some way to health care, companies specifically categorized in the health care services sector accounted for only 0.4 percent of all industrial R&D. In many industries, innovation often results from R&D performed in other industries. This is especially true with respect to health care where R&D in the pharmaceutical, scientific instrument, and software industries all play a role. This illustrates how R&D data disaggregated according to industrial categories (including the distinction between manufacturing and nonmanufacturing industries) may not always reflect the relative proportions of R&D devoted to particular types of scientific or engineering objectives or to particular fields of science or engineering.

R&D IN MANUFACTURING INDUSTRIES

Within the manufacturing industries, three groups dominate: computer and electronic products, transportation equipment, and chemicals (table 5). In 2001 computer and electronic products accounted for the largest amount of R&D performed among all industries

at \$47.1 billion, or 23.7 percent of all industrial R&D and 39.0 percent of all manufacturing R&D. For this subsector, industrial firms provided \$41.2 billion in R&D support and the Federal Government funded the remainder. Reclassifying the R&D of *wholesalers* of computer and electronic products into manufacturing increases the R&D of this group of industries to \$57.9 billion, or 29.2 percent of all industrial R&D. (See sidebar, “Redistributing Trade R&D.”)

In 2001 transportation equipment accounted for the second most R&D performed in the manufacturing sector at \$26.0 billion, or 13.1 percent of all industrial R&D. Of these expenditures, 19.1 percent was federally funded, primarily for R&D on aerospace products (planes, missiles, and space vehicles). In addition to aerospace products, this subsector includes a variety of other forms of transportation equipment, such as motor vehicles, ships, military armored vehicles, locomotives, and smaller vehicles such as motorcycles, bicycles, and snowmobiles.

TABLE 6. Estimated share of company-funded research and development and domestic net sales accounted for by computer-related services industries: 1987–2001

Year	Company-funded R&D	Domestic net sales
1987	3.8	1.4
1988	3.6	1.5
1989	3.4	1.4
1990	3.7	1.5
1991	3.6	1.6
1992	4.0	1.6
1993	8.2	1.5
1994	6.6	2.2
1995	8.8	3.3
1996	8.8	2.6
1997	9.1	2.5
1998	9.5	2.2
1999	10.7	2.6
2000	12.1	2.9
2001	13.2	3.5

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NOTES: Data before 1998 are for companies classified in Standard Industrial Classification (SIC) industries 737 (computer and data processing services) and 871 (engineering, architectural, and surveying services). For 1998 and later years, data are for companies classified in North American Industry Classification System (NAICS) industries 5112 (software), 51 (minus 511, 513) (other information), and 5415 (computer systems design and related services). Using SIC classification, the computer-related services share of company-funded R&D is 10.4 percent for 1998, indicating that SIC-based data are overestimates of actual computer-related services R&D and net sales.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 1987–2001.

In 2001 chemicals ranked third in R&D performed in the manufacturing subsector at \$17.9 billion, approximately 1 percent of which was federally funded. In terms of R&D performance, the largest industry within the chemicals subsector is pharmaceuticals and medicines. In 2001 R&D performed by these companies accounted for 57 percent of non-Federal R&D funding in the chemicals subsector (\$10.1 billion). Reclassifying the R&D of *wholesalers* of drugs and druggists' sundries into manufacturing increases the R&D of pharmaceuticals and medicines to \$18.1 billion and the R&D of chemicals to \$25.9 billion, or 13.0 percent of all industrial R&D. (See sidebar “Redistributing Trade R&D.”)

INDUSTRIAL R&D AND FIRM SIZE

Manufacturing R&D performers tend to be larger firms that perform more R&D on average than nonmanufacturing firms (table 8). As a share of the nation's GDP, manufacturing contributes less than 20 percent, but manufacturing industries account for

61 percent of total industrial R&D performance. Of the approximately 33,000 firms in the United States that performed R&D in 2001, 51 percent were in the manufacturing sector. Manufacturers dominate in terms of R&D performance largely because of the activities of the largest manufacturing firms. In 2001 the largest manufacturing firms (those with 25,000 or more employees) accounted for 49 percent of the R&D in the manufacturing sector, whereas nonmanufacturing firms in the same size category accounted for only 25 percent of total nonmanufacturing R&D.²²

Among smaller R&D-performing firms (those with fewer than 500 employees), those in the nonmanufacturing sector conduct significantly more R&D than those in the manufacturing sector, both in aggregate and on a per-firm basis. These firms accounted for 12 percent of manufacturing R&D, 31 percent of nonmanufacturing R&D, and 19 percent of all industrial R&D in 2001.

Although R&D tends to be performed by large firms in the manufacturing sector and smaller firms in the nonmanufacturing sector, considerable variation can be found within each sector, depending on the type of industry. R&D tends to be conducted primarily by large firms in several industrial subsectors: aircraft and missiles; electrical equipment; professional and scientific instruments; transportation equipment (not including aircraft and missiles); and transportation and utilities, which are in the nonmanufacturing sector. In these same sectors, however, much of the economic activity occurs in large firms to begin with, so the observation that most of the R&D in these sectors is also conducted by large firms is not surprising.

R&D INTENSITY

In addition to absolute levels of and changes in R&D expenditures, another key indicator of industrial commitment to science and technology (S&T) is R&D intensity, a measure of R&D relative to production in a company, industry, or sector. For most firms, R&D is a discretionary expense in the sense that it is not directly related to short-term revenues. Since R&D does not directly generate revenue in the same way that production

²²R&D performance is even more skewed toward companies with large R&D programs (total R&D of \$100 million or more). The 243 firms in this category accounted for 73 percent of manufacturing R&D, 56 percent of nonmanufacturing R&D, and 67 percent of all industrial R&D in 2001.

Biotechnology R&D in Industry

Of particular interest to researchers, investors, and policymakers are the R&D activities of companies in emerging, fast-growing sectors of science and technology such as biotechnology. Unfortunately, the rapidly evolving and often multidisciplinary nature of these sectors makes them very difficult to track as unique industry categories. In 2001, for the first time, NSF collected data on industrial R&D for biotechnology and other select technology areas on its NSF Survey of Industrial Research and Development (only companies with estimated total R&D of at least \$5 million in 2000 were asked to report R&D by technology area in 2001). Although many companies were unable or unwilling to report their R&D activities by technology area, the data reported reveal much about the structure of biotechnology R&D in the United States. As table 7 illustrates, the scientific R&D services industry accounted for slightly more than half

of thereported \$7.4 billion of biotechnology R&D. Many biotechnology firms that perform contract R&D for pharmaceutical companies are classified as part of this industry. Biotechnology R&D accounts for at least a quarter of all R&D in this industry and accounted for at least 3.7 percent of total U.S. industrial R&D in 2001. The \$1.1 billion of biotechnology R&D reported in the trade industry is likely attributable to the activities of pharmaceutical firms, which devote considerable resources to marketing and selling their products. (See sidebar, "Redistributing Trade R&D.") Companies with fewer than 5,000 employees performed nearly three-fourths of the reported biotechnology R&D, whereas companies in this size bracket performed only 38 percent of total industrial R&D in 2001.

TABLE 7. Total research and development and estimated lower bound biotechnology research development, by industry and company size: 2001

Industry and size of company	R&D (millions of dollars)		Percent biotechnology/ total R&D
	Total	Biotechnology	
All industries	198,505	7,350	3.7
Manufacturing	120,705	2,193	1.8
Pharmaceuticals and medicines	10,137	1,882	18.6
Nonmanufacturing	77,799	5,157	6.6
Trade	24,372	1,104	4.5
Scientific R&D services	14,244	3,846	27.0
Company size (number employees)			
Total	198,505	7,350	3.7
5–24	4,828	0	0.0
25–49	3,750	118	3.1
50–99	8,202	398	4.9
100–249	12,916	869	6.7
250–499	8,702	533	6.1
500–999	10,564	1,300	12.3
1,000–4,999	26,748	2,155	8.1
5,000 or more	122,796	1,977	1.6

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NOTES: Details may not add to totals because of rounding. Data for biotechnology R&D are underestimated because no attempt was made to correct for item nonresponse. Counts of respondents suggest that actual figures could be much larger. Also, these totals exclude biotechnology R&D of firms whose total R&D was less than \$5 million in 2000. These firms were not asked to report their biotechnology R&D separately on the 2001 survey form. This may be the main reason firms with 5–24 employees have no reported biotechnology R&D.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2001.

TABLE 8. Funds for industry research and development performance and number of companies performing research and development in manufacturing and nonmanufacturing industries, by size of company: 2001

Company size (number of employees)	Funds (millions of dollars)			Number of companies		
	Total	Manufacturing	Nonmanufacturing	Total	Manufacturing	Nonmanufacturing
Total	198,505	120,705	77,799	33,263	16,817	16,446
5-25	4,828	973	3,855	14,681	5,802	8,879
25-49	3,750	1,123	2,627	5,036	2,013	3,023
50-99	8,202	3,924	4,278	5,030	3,209	1,820
100-249	12,916	4,817	8,099	4,261	2,817	1,444
250-499	8,702	3,345	5,357	1,504	1,040	464
500-999	10,564	5,290	5,273	1,194	851	343
1,000-4,999	26,748	15,828	10,919	1,039	755	284
5,000-9,999	17,487	10,918	6,569	244	164	80
10,000-24,999	27,065	15,647	11,418	156	97	60
25,000 or more	78,244	58,840	19,404	118	68	50

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2001.

expenses do, companies can trim their R&D budgets when profits fall. Evidence suggests, however, that R&D enjoys some degree of immunity from belt-tightening endeavors, even when the economy is faltering, because of its crucial role in laying the foundation for future growth and competitiveness.

Many ways exist to measure R&D intensity; the one used most frequently is the ratio of company-funded R&D to net sales.²³ This statistic provides a way to gauge the relative importance of R&D across industries and among firms in the same industry. The industrial subsectors with the highest R&D intensities in 2001 were scientific R&D services (36.5 percent), software (19.3 percent), communications equipment (16.6 percent), and computer systems design and related services (16.5 percent). The R&D intensities of the professional, scientific, and technical services industries are particularly high because, as previously explained, much of the R&D reported by these companies also appears in their reported sales figures because the R&D activity is the product being sold. Industries with the lowest R&D intensities (0.5 percent or less) were food, broadcasting and telecommunications, and utilities (table 9). A decrease in the net sales of R&D-performing companies between 2000 and 2001 resulted in the ratio

of R&D to sales for all industries increasing to 3.8 percent in 2001, up from 3.4 percent in 2000.

Although overall industrial R&D intensity increased between 2000 and 2001, the R&D intensity of very small companies (less than 100 employees) declined. These companies, on average, have much higher R&D-to-sales ratios than larger companies (table 9) because they include a large number of startups and young companies with less established revenue streams. Large, well-established companies often have reserves of cash and other liquid assets that allow them to maintain their R&D activities amid short-term economic downturns. Less mature companies, however, tend to be more reliant on outside investment and thus their expenditures on R&D are more likely to be cut in the event of a contraction in the economy or capital markets. This is one explanation for the divergence in the R&D intensities of very small companies and all other companies between 2000 and 2001.

FEDERAL R&D PERFORMANCE

Based on data from R&D performers, Federal agencies and FFRDCs performed a projected \$37.1 billion of total U.S. R&D in 2003 (table 1), an average annual increase in real terms of 9.3 percent from the 2000 level of \$27.1 billion.²⁴ Among individual agencies, DOD continued to perform the most intramural R&D and is expected to account for more than half of all Federal obligations for intramural R&D in the future. In FY 2003, DOD is expected to perform more than twice the R&D of the second largest R&D-performing agency,

²³A similar measure of R&D intensity is the ratio of R&D to *value added* (sales minus the cost of materials). Value added is often used in studies of productivity because it allows analysts to focus on the economic output attributable to the specific industrial sector in question by subtracting materials produced in other sectors. For a discussion of the connection between R&D intensity and technological progress, see, for example, R. Nelson, "Modeling the connections in the cross section between technical progress and R&D intensity," *RAND Journal of Economics* 19(3) (Autumn 1988): 478-485.

²⁴Federal intramural R&D obligations are interpreted as R&D performance expenditures for the purpose of this analysis.

TABLE 9. Company and other (non-Federal) research and development as share of net sales in companies performing research and development, by industry and company size: 2000, 2001 (Percent)

Industry and company size	2000	2001
Industry		
All industries	3.4	3.8
Manufacturing	3.3	3.6
Communications equipment	10.1	16.6
Semiconductor and other electronic components	7.4	10.5
Medical equipment and supplies	12.9	9.0
Pharmaceuticals and medicines	9.6	7.8
Computers and peripheral equipment	6.4	7.6
Navigational, measuring, electromedical, and control instruments	8.0	7.3
Resin, synthetic rubber, fibers, and filament	5.6	4.5
Machinery	3.8	4.2
Motor vehicles, trailers, and parts	3.2	3.5
Other chemicals	3.8	3.2
Aerospace products and parts	2.8	3.0
Electrical equipment, appliances, and components	2.2	2.9
Plastics and rubber products	1.4	2.9
Nonmetallic mineral products	1.8	2.3
Basic chemicals	2.3	2.2
Paper, printing, and support activities	1.6	2.1
Fabricated metal products	1.5	1.6
Furniture and related products	0.8	0.9
Primary metals	0.5	0.7
Food	0.4	0.5
Nonmanufacturing	3.8	4.0
Scientific R&D services	34.4	36.5
Software	20.4	19.3
Computer systems design and related services	15.8	16.5
Management of companies and enterprises	4.4	7.8
Trade	5.4	6.2
Architectural, engineering, and related services	7.3	5.2
Health care services	3.2	4.1
Newspaper, periodical, book, and database	2.0	2.7
Transportation and warehousing	0.3	2.4
Construction	1.8	1.4
Mining, extraction, and support activities	1.2	1.3
Finance, insurance, and real estate	1.2	0.7
Broadcasting and telecommunications	0.4	0.5
Utilities	0.1	0.0
Company size (number of employees)		
5-24	17.2	12.9
25-49	13.4	10.6
50-99	11.2	10.4
100-249	8.0	10.8
250-499	6.1	8.0
500-999	4.7	5.7
1,000-4,999	3.5	4.2
5,000-9,999	2.2	2.5
10,000-24,999	3.1	3.5
25,000 or more	2.9	3.0
R&D research and development		

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development, 2001.

HHS, which performs most of its intramural R&D at NIH (table 10).

DOE sponsors the most FFRDCs of any agency—16 of the 36. These 16 FFRDCs performed a total of \$8.7 billion of R&D in FY 2002, approximately three-fourths of all the R&D performed by FFRDCs (appendix table B-15). First established during World War II, FFRDCs are unique organizations that help the U.S. government meet special long-term research or development goals that cannot be met as effectively by in-house or contractor resources. The *Federal Register* states that an FFRDC is required “to operate in the public interest with objectivity and independence, to be free

from organizational conflicts of interest, and to have full disclosure of its affairs to the sponsoring agency” (National Archives and Records Administration 1990). Total R&D performed by all FFRDCs (projected to be \$12.2 billion in 2003) has grown at a real annual rate of 8.1 percent from its level of \$9.2 billion in 2000 (appendix table B-1).

Besides performing R&D directly and funding R&D within other sectors as discussed earlier, the Federal Government also encourages R&D activity indirectly in the form of tax incentives. (See sidebar, “Federal R&D Tax Credit.”)

TABLE 10. Federal research and development obligations, total, intramural, and federally funded research and development centers, by U.S. agency: FY 2003

Agency	Federal R&D obligations (millions of dollars)			Percent agency intramural or FFRDC R&D
	Total	Intramural ^a R&D	FFRDC R&D	
All Federal Government	98,608.1	24,557.7	7,534.6	32.5
Department of Defense	45,011.7	12,409.0	851.3	29.5
Department of Health and Human Services	27,551.1	5,162.4	403.9	20.2
National Aeronautics and Space Administration	8,598.3	2,149.6	1,405.3	41.3
Department of Energy	7,540.7	764.4	4,609.3	71.3
National Science Foundation	3,403.6	19.4	197.5	6.4
Department of Agriculture	1,984.3	1,367.2	0.0	68.9
Department of Commerce	1,064.5	838.0	2.9	79.0
Environmental Protection Agency	627.0	283.8	0.0	45.3
Department of Transportation	622.0	192.3	24.8	34.9
Department of the Interior	594.1	534.8	0.0	90.0
Department of Veterans Affairs	363.7	363.7	0.0	100.0
Department of Education	304.5	14.4	0.0	4.7
International Development Cooperation Agency	281.0	27.5	0.0	9.8
Department of Labor	176.8	154.9	0.0	87.6
Department of Justice	117.6	43.2	3.4	39.6
Smithsonian Institution	115.0	115.0	0.0	100.0
Department of the Treasury	80.4	64.4	0.0	80.1
Nuclear Regulatory Commission	68.0	18.7	36.1	80.6
Department of Housing and Urban Development	47.7	23.6	0.0	49.5
Social Security Administration	45.5	4.4	0.0	9.7
Library of Congress	3.5	2.5	0.0	71.4
Department of State	2.5	0.6	0.0	24.0
Federal Communications Commission	2.2	2.2	0.0	100.0
Federal Trade Commission	1.4	1.4	0.0	100.0
Appalachian Regional Commission	0.7	0.0	0.0	0.0
Broadcasting Board of Governors	0.1	0.1	0.0	100.0
National Archives and Records Administration	0.1	0.1	0.0	100.0

FFRDC federally funded research and development center
R&D research and development

^a Intramural activities include actual intramural R&D performance and costs associated with planning and administration of both intramural and extramural programs by Federal personnel.

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Federal Funds for Research and Development: FY 2001, 2002, and 2003.

Federal R&D Tax Credit

The Federal research and experimentation (R&E) tax credit was first established on a temporary basis in 1981 and has been renewed over ten times since through various tax legislation. It was last reinstated by the Tax Relief Extension Act of 1999 through June 30, 2004. As of this writing, legislation is pending to further extend the R&E credit.

A regular credit is provided for 20 percent of qualified research above a base amount based on the ratio of research expenses to gross receipts for 1984–88. Startup or younger companies follow different formulas. An alternative R&E credit is available for corporate fiscal years that began after June 30, 1996. Both the regular and the alternative R&E credits include provisions for basic research payments paid to qualified universities or scientific research organizations above a certain base-period amount.

In 1999 approximately 10,000 companies claimed \$5.281 billion in R&E credits, about the same level as in 1998 (table 11). However, not all R&E claims are allowed because there is a limitation on the reduction of a company's total tax liability. In 1999, 267 companies claimed \$540 million for basic research, about 10 percent of the total R&E credit. The 1999 basic research credits were 36 percent larger than those in 1998, but the number of claims declined by half.

R&E credits are tax expenditures or government revenue losses because of preferential provisions.

Table 11. Research and experimentation tax credit claims: 1990–99

Year	Billions of current dollars	Number of tax returns
1990	1.547	8,699
1991	1.585	9,001
1992	1.515	7,750
1993	1.857	9,933
1994	2.423	9,150
1995	1.422	7,877
1996	2.134	9,709
1997	4.398	10,668
1998	5.208	9,849
1999	5.281	10,020

SOURCE: U.S. Department of the Treasury, Internal Revenue Service, Statistics of Income, unpublished tabulations.

Tax expenditures from corporate income taxes relate mostly to cost recovery for certain investments, including research activities. One accounting method used to estimate the impact of a tax credit is called outlay-equivalent. This method converts R&E credits into data comparable to Federal R&D outlays.

According to this measure, tax credit claims in 1999 were equivalent to outlays of \$2.625 billion, or 3.5 percent of direct Federal R&D outlays in 1999 (appendix table B-16). Although R&E claims data for tax year 2000 are not yet released, the credit generated an estimated outlay equivalent of \$2.510 billion, or 3.4 percent, of Federal R&D outlays in 2000.

UNIVERSITY AND COLLEGE R&D PERFORMANCE

Universities and colleges performed a projected \$40.3 billion of R&D in 2003, an average annual increase in real terms of 7.9 percent from the 2000 level of \$30.6 billion. The Federal Government is the largest source of support for academic research in the United States, funding an estimated 60.8 percent (\$24.5 billion) of academic R&D in 2003. The next largest source of support for academic R&D is university-own funds (19.7 percent in 2003) followed by nonprofit institutions (7.4 percent), state and local governments (6.7 percent), and industry (5.3 percent).

Although industrial firms provide only a small portion of the R&D funding at U.S. universities and colleges, their funding of academic research has grown faster than any other sector over the past 2 decades. Between 1980 and 2000, industry's funding of academic R&D grew at an average annual rate of 7.7 percent after adjusting for inflation, outpacing total academic R&D, which grew at an average annual rate of 4.7 percent over the same period. After adjusting for inflation, industry's funding of academic R&D declined at an average annual rate of 2.2 percent between 2000 and 2003, lessening at about the same rate as industry's R&D funding of industrial R&D.

FUNDING BY TYPE OF INSTITUTION

Although both public and private colleges and universities rely on the same funding sources for their R&D, the relative importance of those sources differs substantially for these two types of institutions (figure 15). For all public academic institutions combined, just over 9 percent of R&D funding in 2001 came from state and local governments, about 25 percent came from institutions, and about 52 percent came from the Federal Government. Private academic institutions received a much smaller portion of their R&D funding from state and local governments (about 2 percent) and institutional sources (about 10 percent) and a much larger share from the Federal Government (72 percent). The large difference in the role of institutional funds at public and private institutions is most likely due to a substantial amount of general-purpose state and local government funds that public institutions receive and decide to use for R&D (although data on such breakdowns are not collected). Both public and private institutions received approximately 7 percent of their respective R&D support from industry in 2001. Over the past 2 decades, the Federal share of support has declined, and the industry and institutional shares have increased for both public and private institutions.

DISTRIBUTION OF R&D FUNDS ACROSS ACADEMIC INSTITUTIONS

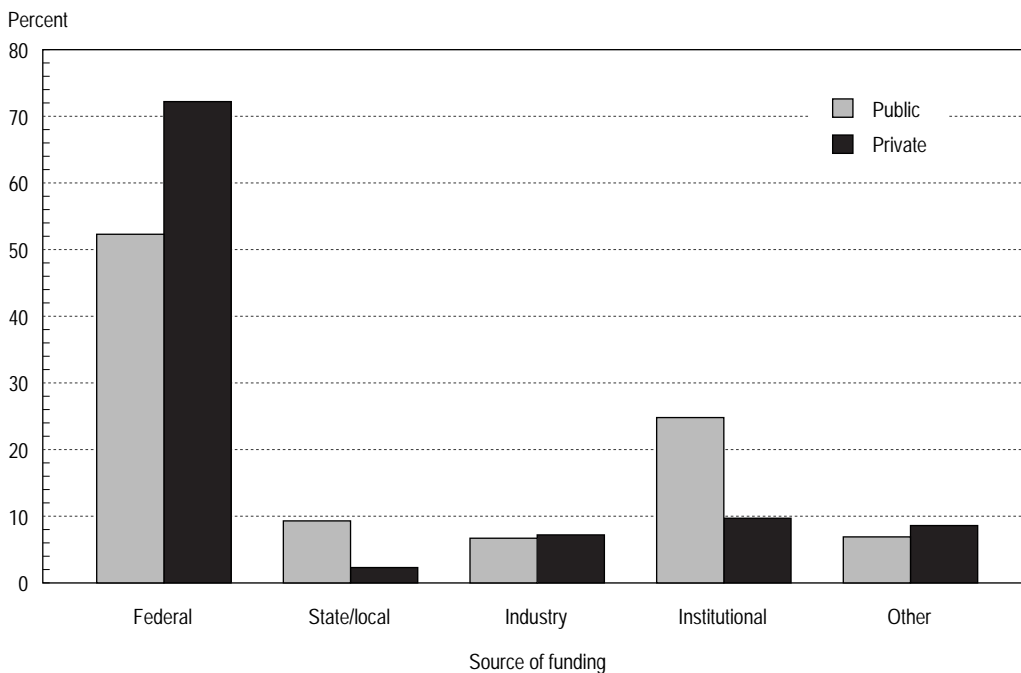
Most academic R&D is now, and has been historically, concentrated in relatively few of the 3,600 U.S. institutions of higher education.²⁵ The top 200 institutions ranked by total R&D expenditures accounted for about 96 percent of 2001 R&D expenditures. In 2001:

- The top 10 institutions spent 17 percent of total academic R&D funds (\$5.5 billion).
- The top 20 institutions spent 30 percent (\$9.8 billion).
- The top 50 spent 57 percent (\$18.6 billion).
- The top 100 spent 80 percent (\$26.3 billion).

The historic concentration of academic R&D funds diminished somewhat between the mid-1980s and mid-1990s but has remained relatively steady since then (figure 16). In 1985, the top 10 institutions received about

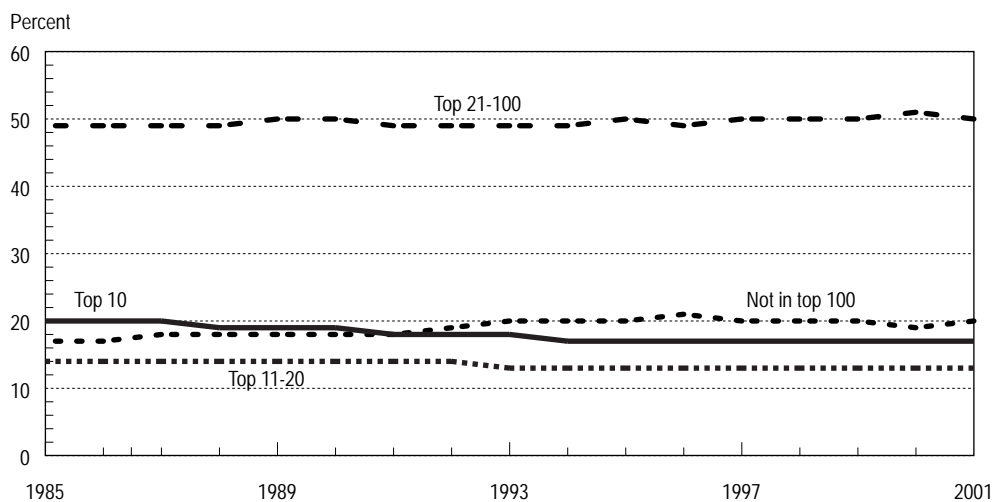
²⁵The Carnegie Foundation for the Advancement of Teaching classified about 3,600 degree-granting institutions as higher education institutions in 1994.

FIGURE 15. Sources of research and development funding for public and private academic institutions: 2001



SOURCE: National Science Foundation, Division of Science Resources Statistics, *Academic Research and Development Expenditures: Fiscal Year 2001* (Arlington, VA, 2003).

FIGURE 16. Share of academic research and development of universities and colleges, by rank of academic research and development expenditures: 1985–2001



SOURCE: National Science Foundation, Division of Science Resources Statistics, *Academic Science and Engineering R&D Expenditures: Fiscal Year 2001*, special tabulations.

20 percent of the nation’s total academic R&D expenditures and the top 11–20 institutions received 14 percent, compared with 17 and 13 percent, respectively, in 2001. The composition of the universities in the top 20 also fluctuated slightly from 1985 to 2001. There was almost no change in the share of the group of institutions ranked 21–100 during this period. The decline in the top 20 institutions’ share was matched by an increase in the share of those institutions in the group that were not in the top 100. This group’s share increased from 17 to 20 percent of total academic R&D funds, signifying a broadening of the base.

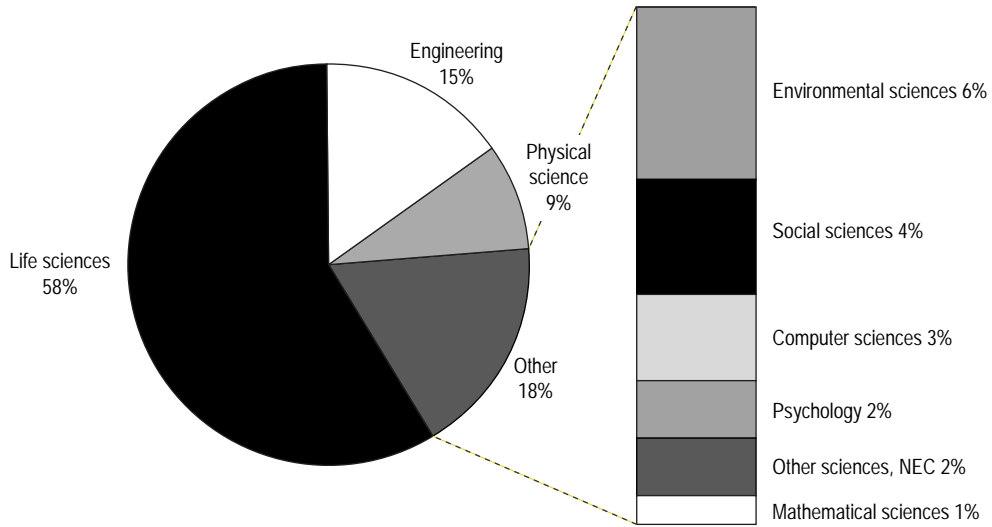
FUNDING BY S&E FIELD

Many universities and colleges are able to report their total and federally financed R&D expenditures for separate fields of science and engineering. The majority of academic R&D expenditures are devoted to the life sciences (figure 17)—approximately four times the expenditures for the next largest field, engineering. Despite dramatic growth in Federal funding of R&D in the life sciences (particularly from NIH), Federal funding represents a smaller share of total R&D in this field than

in many others. R&D in the physical sciences, mathematical sciences, and psychology, for example, show a higher concentration of Federal funding. The social sciences is the only group of fields that receives less than half of its funding from Federal sources (NSF, Division of Science Resources Statistics 2003).

Although there is no detailed information about the various non-Federal sources of academic R&D funding broken out by S&E field, it is possible to make some general observations. Agricultural sciences (a subset of life sciences) R&D, for example, is concentrated in public universities and colleges and receives most of its funding from non-Federal sources. It is fair to assume that most of this non-Federal funding comes from state and local governments and university-own funds. There also appears to be a correlation between industry funding and both medical sciences (a subset of life sciences) and engineering. Conversations with representatives of several large research universities confirmed that, at least for these schools, industry-funded R&D is concentrated in the fields of medical sciences and engineering.

FIGURE 17. Academic research and development, by field of science and engineering: FY 2001



NEC Not elsewhere classified

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

SOURCE: National Science Foundation, Division of Science Resources Statistics, *Academic Research and Development Expenditures: Fiscal Year 2001* (Arlington, VA 2003).