RAND

Federal Investment in R&D

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This is a final report of a project. It has been formally reviewed but has not been formally edited.

FOREWORD

by

Erich Bloch, The Washington Advisory Group

and

Member of the President's Council of Advisors on Science and Technology (PCAST)

The charter of PCAST's Panel on Federal Investment in Science and Technology and Its National Benefits is to review the federal government's research and development (R&D) portfolio and make recommendations on areas where programs should be expanded, curtailed, or maintained. It is planned that the Panel's observations and recommendations be made in time to provide input to the President's budget submission to Congress for Fiscal Year 2004.

It was clear from the outset that the federal R&D budget could not be discussed in isolation, but needed to be viewed in conjunction with total U.S. R&D spending, including industrial R&D and state and not-for-profit foundation R&D spending. Similarly, the Panel wanted to focus its recommendations comprehensively on total national benefits rather than be limited to economic results or government responsibilities.

Another ground rule was that the time frame for the review should go back to 1975. After all, many of today's realities are outgrowths of activities put into place over this time interval. The primary sources of data are the American Association for the Advancement of Science's (AAAS) Federal R&D Budget Analysis, the National Science Foundation's (NSF) Survey of Federal Funds for Research and Development, and Survey of Graduate Students and Postdoctorates in Science and Engineering, the National Science Board's Science and Engineering Indicators, and the Organisation for Economic Co-operation and Development (OECD) Main Science and Technology Indicators. All these can provide important insights.

RAND's Science and Technology Policy Institute was charged with crafting, together with the help of AAAS, a succinct, factual story on the federal investment in R&D, resulting in this report. The following issues were raised by the Panel and the report's structure follows them:

1. Federal R&D. Identify major changes in federal R&D policy and spending since 1975. Account for changes in the overall size of the federal R&D portfolio as well as changes in its internal composition and discuss the possible reasons for such changes.

2. Non-federal R&D. Identify major changes in private sector, state, and other major non-federal R&D spending, since 1975. Account for changes in the overall size of these R&D portfolios as well as their internal composition and discuss possible reasons for such changes.

3. R&D Balance. Identify changes since 1975 in the balance of funding among the fields of science and engineering that constitute the federal R&D portfolio. Identify current trends in the balance of funding among these fields and explore the possible ramifications of such trends.

4. Education, Workforce and Research Outputs. Identify changes in U.S. science and engineering graduate education and the U.S. scientific and technological workforce. Identify changes in patents awarded to U.S. universities and colleges and articles published in major scientific and technical journals. Explore the possible ramifications of these trends for U.S. productivity and economic growth.

5. International Comparison. Compare U.S. R&D spending with comparable spending by the European Union, Japan, China and other major R&D-performing nations.

The federal R&D budget and this report reflect not only the activities of government agencies and their contractors but to a great extent reflect the administration's and Congress's changes in policy over the last 25 years. We want to highlight and comment on the most salient observations this review reveals and identify some of the issues that PCAST needs to address.

While federal R&D since 1975 has steadily declined as a percentage of GDP and as a percentage of the federal budget, it nevertheless has almost doubled in real dollars (five-fold in current dollars). The relative priority of R&D programs and activities, however, has varied greatly. This raises two issues:

- Is there a proper and optimum balance of federal R&D expenditures?
- Should federal R&D increase as a share of GNP or at least keep pace with economic growth?

The organizational aspects of the federal R&D budget are diffused among many departments, agencies, and congressional committees. The coordination of such a vast and distributed enterprise is therefore important. The Panel

- needs to understand the organizational constructs that serve this purpose and
- identify areas that are not addressed and others that could benefit from special attention.

Total U.S. R&D has increased more than two and a half times in real dollars since 1975, a greater growth than federal R&D by itself. Aside from this growth, there has been a shift in the ratio of private sector R&D to federal R&D. Today this ratio is 3:1, compared to 1:1 in 1976. This shift brings with it a change in the character of U.S. R&D. Development is 61 percent of R&D, while basic research amounts to 18 percent and applied research to 21 percent. PCAST has to assess

- this shift in R&D sponsorship, especially the stability of the distribution between the main contributors, and
- the adequacy of basic and applied research to fuel the nation's future development needs.

A review of the last 25 years of R&D funding shows the rather large changes in the areas supported. There are not only changes between defense and civilian R&D caused by changes in the international political climate, but also rather large shifts in funding among science and engineering disciplines, such as the physical and life sciences. The questions for PCAST are:

- Does the shift in support for certain disciplines jeopardize others in a significant way, and what needs to be done to keep track of these issues in order to correct them?

- Because of lack of support for key disciplines, is the United States threatened with a decline in human resources and infrastructure in these affected areas?

Human resources in science and engineering (S&E) are a continuous issue in the United States The number of full-time graduate students in most fields of science and engineering has either declined or been stagnant. The number of doctorates awarded in S&E have increased, primarily because of the high influx of foreign-born students. Of late, even this trend has leveled off as some foreign countries have expanded their institutional capacity for S&E graduate programs and doctoral education. No issue is more paramount for PCAST and its need to

- assess the adequacy of the nation's S&E human resources,
- identify who in the federal government has the responsibility to focus on the health of our S&E human resources, and
- determine what programs are needed to counteract shortages, if they exist.

A comparison of the United States with other countries that play a key role in research and development raises a number of questions:

- What nations are going to be more involved in R&D in the future?
- How does the United States compare to other countries in investment and results in key R&D areas?
- What international programs should be considered and would best serve our purposes?

While these are daunting issues, this report provides the analytical base to address the more urgent ones.

The Panel thanks Elisa Eiseman, Kei Koizumi, and Donna Fossum for the excellent work they did in preparing this report.

EB: June 22, 2002

ABOUT RaDiUS

RAND's Research and Development in the United States (RaDiUS) database is a comprehensive, real-time accounting of federal R&D activities and spending. RaDiUS allows users to see the total R&D investment by all federal agencies, to compare the level of R&D investment in specific areas of science and technology across all federal agencies, or to examine the details of research investments within a specific agency (for more information about RaDiUS see http://www.rand.org/scitech/radius/). RaDiUS was consulted during the preparation of this report, and was used to provide PCAST with fiscal year 2003 estimates of federal budget authority for science and engineering research.

RaDiUS was created by RAND, in cooperation with the NSF, to assist RAND's Science and Technology (S&T) Policy Institute in providing analytical support to the White House Office of Science and Technology Policy (OSTP) and the National Science and Technology Council (NSTC). The RaDiUS Team, a group of researchers at RAND specializing in the analysis of federally funded R&D, was integral to the preparation of this report for PCAST.

ABOUT THE S&T POLICY INSTITUTE

Originally created by Congress in 1991 as the Critical Technologies Institute and renamed in 1998, the *Science and Technology Policy Institute* is a federally funded research and development center sponsored by the NSF and managed by RAND. The Institute's mission is to help improve public policy by conducting objective, independent research and analysis on policy issues that involve science and technology. To this end, the Institute

- Supports the OSTP and other Executive Branch agencies, offices, and councils
- Helps science and technology decisionmakers understand the likely consequences of their decisions and choose among alternative policies
- Helps improve understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives.

In carrying out its mission, the Institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

Inquiries regarding the Science and Technology Policy Institute may be directed to the addresses below.

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DEFINITIONS OF "RESEARCH AND DEVELOPMENT" AND OTHER TERMS

At numerous points in this document, the phrases "research and development" (R&D) and "science and technology" (S&T) are used. When used specifically to describe budgetary activity, these phrases take on specific meanings. All data related to **R&D** are based on the definitions employed by the Office of Management and Budget (OMB), the National Science Foundation (NSF), the R&D Budget and Policy Program of the American Association for the Advancement of Science (AAAS), and other federal agencies. All R&D data use the common definitions below:

In this report, **R&D** (or "total R&D") refers to both the conduct of research and development as well as R&D facilities. The following definitions are used by the Office of Management and Budget, the National Science Foundation, and AAAS:[1]

Research is systematic study directed toward fuller scientific knowledge or understanding of the subject studied. The federal government categorizes research as either basic or applied according to the objectives of the sponsoring agency.

- In **basic research**, the objective is to gain fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind.

- In **applied research**, the objective is to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.

Development is the systematic application of knowledge or understanding directed toward the production of materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements. The term excludes quality control, routine product testing, and experimental production.

R&D funding normally includes personnel, program supervision, and administrative support costs directly associated with R&D activities. Laboratory equipment is also included. Defense R&D also includes testing, evaluation, prototype development, and other activities that precede actual production.

Funding for **R&D facilities** (also known as R&D plant) includes construction, repair, or alteration of physical plant (e.g., reactors, wind tunnels, particle accelerators, or laboratories) used in the conduct of R&D. It also includes major capital equipment used for R&D.

Most of the federal R&D funding data in this report are presented in terms of **budget authority** or **obligations**. Budget authority is the initial budget parameter for congressional action on the President's proposed budget. Other R&D data sources may express R&D funding in terms of **outlays**, for data sets compiled from retrospective surveys of funding agencies and recipients.

[1]Definitions adapted from Office of Management and Budget Circular No. A-11.

Budget authority is the legal authorization to expend funds.

Obligations represent orders placed, contracts awarded, services received, and similar transactions entered into during a given period, regardless of when the funds were appropriated and when the future payment of money is required.

Outlays represent checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated. Some surveys refer to outlays as **expenditures**.

Although *science and technology* is used often as generic terminology, in R&D budget data the generic terms take on specific meanings. In the Department of Defense (DOD), **Science and technology (S&T)** refers specifically to the basic research, applied research, and advanced technology development portions of the overall DOD R&D budget ("6.1" through "6.3" in DOD budget terminology), excluding the weapons systems development work that makes up the majority of DOD R&D ("6.4" through "6.7"). Weapons systems development spending is sometimes excluded from discussions of R&D because these investments are uniquely military and are highly specific applications, with little impact on the U.S. civilian economy or knowledge base.

In a 1995 report, the National Academy of Sciences (NAS) Committee on Criteria for Federal Support of Research and Development proposed an alternative method to measure the federal investment in science and technology called the Federal Science and Technology (FS&T) budget (NAS, 1995). The **FS&T budget** included only the federal R&D dollars spent annually on expanding fundamental knowledge and creating new technologies and excluded activities such as the testing and evaluation of new weapons systems. In the fiscal year (FY) 1999 Budget of the United States, the "Research Fund for America" (RFA), a concept similar to the FS&T budget, was introduced. The RFA consisted of only nondefense R&D, and included some non-R&D programs, such as NSF education programs and staff salaries at the National Institutes of Health (NIH) and NSF. In contrast to the FS&T budget, which was constructed from components of the R&D budget, the RFA was constructed of programs that could be easily tracked in the budget process. The FY 2000 budget contained a slight modification of the RFA called the "21st Century Research Fund." More recently, OMB introduced a new FS&T budget in the FY 2002 budget and continues to use this concept in the FY 2003 budget. OMB's FS&T budget is the successor to the Clinton Administration's "21st Century Research Fund" and contains most of the same programs. Unlike R&D, there are no set definitions for FS&T and thus the composition of the FS&T portfolio has shifted; it is a collection of federal programs designed to be easy to track in the budget process rather than a comprehensive inventory of federal science and technology investments. FS&T is a collection of R&D and non-R&D programs selected by OMB that emphasize basic and applied research and the creation of new knowledge or technologies. It also includes some S&T education and training activities but excludes most development (such as DOD weapons systems development), and is designed to be an alternative measure for the federal investment in science and technology and an alternative way to track federal S&T investments in the budget process. Thus, OMB's FS&T budget has a similar emphasis but is different from the FS&T concept proposed in 1995 by the NAS as a subset of federal R&D (NAS, 1995).

USER NOTES

Constant Dollars

Year-to-year changes or historical data series are usually expressed in constant dollars to remove the effects of inflation. Funding data in this report have been converted to constant dollars using the GDP deflators found in Historical Table 10.1 of the OMB *Budget of the United States Government, Fiscal Year 2003*.

Purchasing Power Parity

International R&D funding data in this report are presented in two ways: 1) as a ratio of R&D spending to the gross domestic product, which provides an indication of R&D spending relative to the total economic activity of a country; and 2) converted to U.S. dollars using purchasing power parity (PPP) exchange rates as an indicator of absolute effort. PPP exchange rates are based on estimates of the purchasing power of different currencies, and are used to equalize price levels across countries. In other words, the theory behind PPP is that the price of identical goods in different countries should be equal after adjusting for the rate of exchange between currencies.

Historical Data Series

Many historical data series of R&D by performer, discipline, and character, as well as data on R&D expenditures by nonfederal funding sources, are compiled from detailed surveys of agencies and performers conducted by the NSF's Division of Science Resources Statistics (SRS). SRS conducts annual surveys (using the definitions above, as well as standardized definitions of science and engineering disciplines, performer categories, etc.) of federal agencies, industrial performers, universities and colleges, and nonprofit organizations to determine the actual disbursement of federal funds allocated to R&D in the budget process and to determine the composition of nonfederal expenditures on R&D. NSF submits U.S. data on R&D to the OECD, which compiles R&D data for its member nations and selected other nations using standardized definitions and reporting standards.

Data for FY 2000 and Preliminary Data for FY 2001 and FY 2002

Each year, the NSF Survey of Federal Funds for Research and Development collects information on the previous year's actual obligations and on preliminary estimates for the next two years. The most-recent data available from NSF were collected in FY 2001; therefore, the most current data available are for FY 2000, with preliminary estimates available for FY 2001 and FY 2002. Since data for the FY 2001 were collected well into that fiscal year (about 6 to 10 months after the start of the fiscal year), the preliminary estimates are generally a good indication of the actual levels that will be reported in later surveys (NSF, 2002a). Estimates for FY 2002, however, are based mainly on the agencies' budget requests, which frequently differ from actual appropriations; therefore data for FY 2002 are more speculative.

American Association for the Advancement of Science Data Sources

AAAS derives its data from OMB data and data provided by the various federal agencies that perform R&D. OMB requires agencies to submit data on R&D programs as part of their annual budget submissions. Specifically, agencies provide data (reported on MAX Schedule C as part of the budget process) on funding levels for basic research, applied research, development, R&D facilities, and major capital equipment for R&D. These R&D figures rarely correspond to budget line items as found in appropriations bills or the President's budget. Agencies make determinations as to what proportion of budget line items is classified as R&D; many budget line items have both R&D and non-R&D components. Agencies also differ in their reporting. For example, some agencies classify program direction or management support as R&D; others do not. Some data are collected by AAAS from individual agencies after the release of the budget, and reflect agency and AAAS revisions to OMB-submitted data. The motivation of the AAAS effort is to wade through these disparate agency approaches counting only those items deemed to be R&D.

Fields of Science and Engineering

In the Survey of Federal Funds for Research and Development, NSF collects data on federal obligations for basic research and applied research in S&E, classified in eight broad research fields consisting of a number of detailed fields (see Appendix I, Table 1). The broad fields are life sciences, psychology, physical sciences, environmental sciences, mathematics and computer sciences, engineering, social sciences, and other sciences not elsewhere classified (n.e.c.). The term *not elsewhere classified* is used for multidisciplinary projects within a broad field and for single-discipline projects for which a separate field has not been assigned. Table 1 presents the detailed fields grouped under each of the broad fields, together with illustrative disciplines of detailed fields.

The Survey only collects S&E field data for federal funding of basic research and applied research. It does not collect S&E field data for development or R&D plant funds. In addition to collecting data on the past year's funding, the Survey also collects preliminary estimates from federal agencies on allocations for the current and next fiscal years for the broad fields of S&E; however, data on the detailed fields are not collected.

Reclassification of Federal Obligations for Research

From time to time, agencies responding to the NSF Federal Funds Survey change their procedures for classifying research obligations by field of research. These changes can have profound effects on the apparent distribution of funding for S&E fields. For example, in FY 1996, NSF changed its classification of engineering and the environmental sciences research activities so that its support of mechanical engineering appeared to be much less and its funding of oceanography much greater. In FY 2000, the National Aeronautics and Space Administration (NASA) and the NIH reclassified their R&D and R&D plant funds. NASA reclassified the Space Station as a physical asset and Space Station Research as equipment, and transferred funding from "R&D" to "R&D Plant." NIH reclassified all of its "development" into "research" (mainly applied research) (NSF, 2002a).

The NASA reclassification resulted in the agency reporting a $2.3 billion decline in FY 2000 budget obligations for development activities from their FY 1999 levels, and a comparable $2.5 billion increase in obligations for R&D plant (NSF, 2002a). Conversely, NASA's reclassification did not significantly affect the S&E research field distributions, since most of its changes had an impact on its development and R&D plant totals. The NSF Federal Funds survey does not collect S&E field data for development or R&D plant funds. However, there were also substantial changes in reported obligations for NASA's basic research and applied research that probably are unrelated to Space Station reclassifications and these confound analyses of the agency's overall funding trends (NSF, 2002a).

NIH reclassified all of what it previously called "development" activities as "research" (NSF, 2002a). This reclassification resulted in NIH reporting a $2.2 billion decline in FY 2000 budget obligations for development activities from their FY 1999 levels (NSF, 2002a). Most of the development funds are now classified as applied research, and only a small amount was reclassified as basic research (NSF, 2002a). NIH's applied research obligations grew 35 percent between FY 1999 and FY 2000, and basic research grew 16 percent.

In addition to affecting the distribution of funds by character of work, the NIH reclassification of development funds also significantly affected the distribution of funding of S&E research fields. NIH funding of most S&E research fields changed significantly between FY 1999 and FY 2000 (see Appendix I, Table 2). Reclassification of development funds by NIH resulted in apparent substantial increases in FY 2000 for psychology (199.3 percent), physical sciences (193.5 percent), environmental sciences (800.6 percent), engineering (102.5 percent), and social sciences (90.9 percent) (NSF, 2002a). Several of the major shifts in funding of the broad fields can be accounted for by changes in one of the component detailed fields. For example, in psychology, the major changes in funding occurred in the detailed field of psychological sciences, n.e.c. (an apparent 213.7 percent increase); in the environmental sciences, the change can be accounted for by changes in environmental sciences, n.e.c. (an apparent 800.6 percent increase); and in the physical sciences, most of the change can be attributed to a large increase in funding of chemistry (an apparent 221.7 percent increase). In addition, two detailed fields of S&E that NIH started funding in FY 2000 were not funded in FY 1999: physical sciences, n.e.c., and metallurgy and materials engineering. There were also several fields that were funded in FY 1999 but not in FY 2000: environmental biology, biological and social aspects of psychology, physics, computer sciences, and sociology.

The reclassification of R&D and R&D plant funding at NASA and NIH had a significant impact on the overall federal funding trends between FY 1999 and FY 2000. Between FY 1999 and FY 2000, basic research and applied research increased in real terms by 10 percent and 15 percent, respectively (NSF, 2002a). R&D plant obligations apparently grew by 125 percent, whereas development obligations plummeted by 42 percent (NSF, 2002a). Some portion of these changes was probably due to actual funding trends (for example, basic and applied research each have been annually increasing since FY 1996) (NSF, 2002a). The majority, however, probably resulted from agencies' revised reporting categorizations (NSF, 2002a). Therefore, reclassification of R&D and R&D plant funding by federal agencies affects funding trends in both the character of work and S&E research fields, confounding any attempts to analyze balance in the federal R&D portfolio.

CHAPTER 1

The President's Council of Advisors on Science and Technology (PCAST) Panel on Federal Investment in Science and Technology and its National Benefits was formed to examine trends in federal funding of research and development (R&D) and determine whether these trends were consistent with the nation's present and future needs. The following issues were raised by PCAST:

> Identify major changes in federal R&D policy and spending since 1975. Account for changes in the overall size of the federal R&D portfolio as well as changes in its internal composition and discuss the possible reasons for such changes.

To obtain the necessary facts and figures from which it could draw insights and conclusions, PCAST asked for data on the major changes in federal R&D policy and spending over the last 25 years.[2]

Trends in the Federal R&D Portfolio

Total federal R&D would be at an all-time high in inflation-adjusted terms in fiscal year (FY) 2003 if President Bush's proposals are approved. As Figure 1-1 shows, over the past two and a half decades the trend has been of increasing federal support of R&D, from $60 billion in today's (constant FY 2002) dollars in FY 1976 to over $110 billion in the FY 2003 proposal. These increases, however, have not enabled the federal R&D to grow as a percentage of the U.S. gross domestic product (GDP) (see discussion on page 18). In addition, significant upheavals in federal R&D funding have taken place during this period.

Unlike many other nations, in which government R&D is funded predominantly by a single science agency under the goal of advancing science, the U.S. federal R&D funding system is mission oriented. R&D programs are funded according to their contributions to national goals and broad national missions, each of which is the responsibility of a different government agency or agencies.

From the standpoint of serving the nation's interests, this system makes good sense, since these R&D programs are not ends in themselves but means to the ends (missions) that their sponsoring agencies serve; this system helps to link R&D programs with policy outcomes. From the standpoint of the long-term health of the research enterprise, however, this system may cause problems. The mission orientation of R&D programs may make it difficult for policymakers to assess the overall health of the R&D enterprise, to coordinate programs among different agencies serving different missions, and to address issues of balance among various scientific and engineering fields (see explanation of PCAST Issue Number 3 on R&D Balance for data on federal funding of science and engineering fields).

The relative priority of different R&D programs has varied considerably over the years, reflecting changing national priorities and the role of R&D within them. The federal budget is

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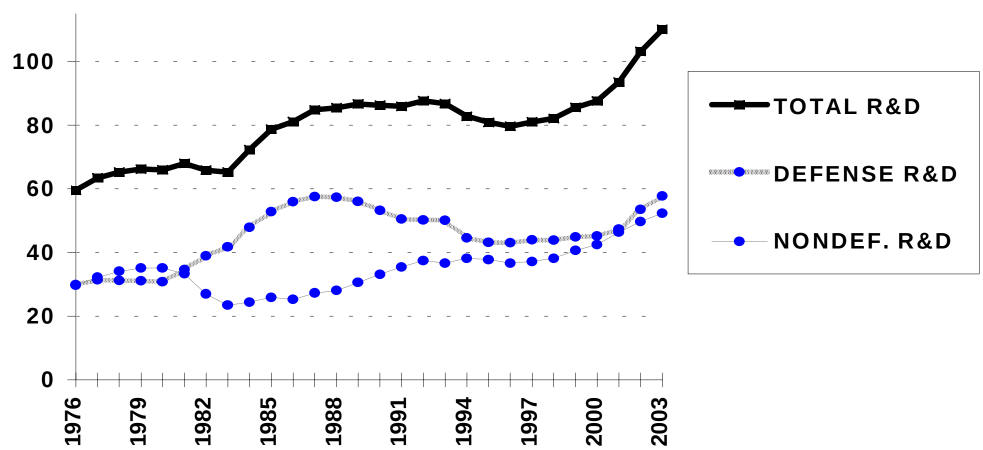
[2] AAAS began collecting and analyzing data on federal R&D spending in FY 1976. The information presented in this chapter is based on the AAAS data, and therefore includes FY 1976 through FY 2003.

formally classified into 20 different functions, or missions; R&D contributes to 15 of these missions, though for most missions the contribution is rather small (NSF, 2001a).

The largest federal mission for R&D has always been national defense. Spending on defense R&D has exceeded all other R&D spending (grouped together as "nondefense R&D") for most of the past several decades, although the relative size of the two sectors has varied considerably over the years (see Figure 1-1 and Appendix I, Table 3). Defense and nondefense R&D have followed divergent paths during the past 25 years, and have tended to move in mirror images of each other until the last few years, when both have been increasing. In FY 1976, defense and nondefense R&D were roughly equal shares of the federal R&D portfolio; after diverging in FY 1982, only in FY 2001 did funding levels approach convergence once again (the FY 2003 budget would increase defense R&D at a greater rate than nondefense R&D).

Figure 1-1. Trends in Federal R&D. FY 1976–2003
(budget authority in billions of constant FY 2002 dollars)



Source: AAAS analyses of R&D in *AAAS Reports I-XXVII.* FY 2003 figures are President's request; FY 2002 figures are latest estimates. Includes conduct of R&D and R&D facilities. Constant dollar conversions based on OMB's GDP deflators.
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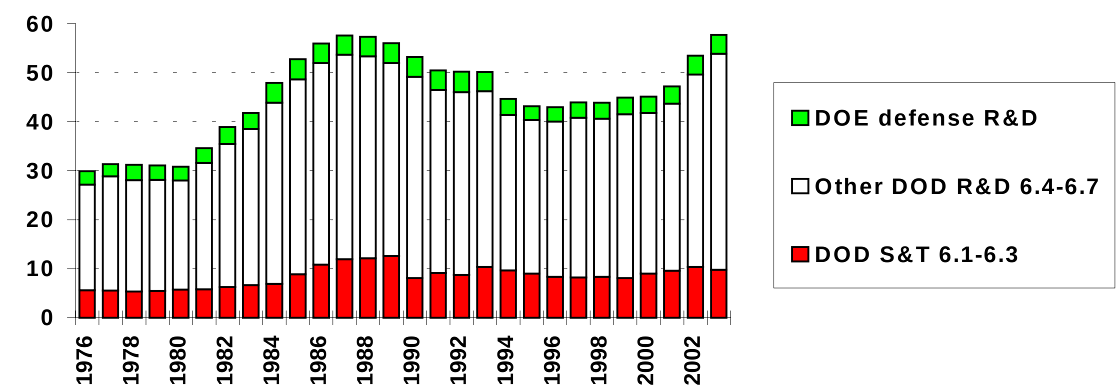
For defense R&D, the most significant trend of the past three decades, as shown in Figure 1-2, has been the dramatic Reagan Administration–era buildup of defense development, followed by equally dramatic post–Cold War cutbacks. From FY 1980 to its peak in FY 1987, defense R&D nearly doubled in real terms as the United States embarked upon a substantial increase in all forms of defense spending, motivated by high Cold War tensions with the Soviet Union and emerging technological priorities, such as the Strategic Defense Initiative. By FY 1987, defense R&D was two-thirds of total R&D, but then funding fell dramatically even before the end of the Cold War. The slide accelerated in the 1990s as the Department of Defense (DOD) and the defense-oriented activities of the Department of Energy (DOE) transitioned to the post–Cold

War era. After bottoming out in FY 1996, defense R&D has been increasing for the past several years.

As the figure shows, nearly all of the defense R&D investment is in the development, testing, and evaluation of specific weapons systems ("6.4" through "6.7" categories in DOD terminology), and this investment fluctuates according to the number and expense of weapons systems in the development stage and the relative priority assigned to weapons development within the Pentagon budget. Weapons development increased dramatically in the 1980s but then fell in the post–Cold War era; in more recent years, weapons development has increased dramatically again.

Figure 1-2. Trends in Defense R&D: FY 1976–2003
(budget authority in billions of constant FY 2002 dollars)

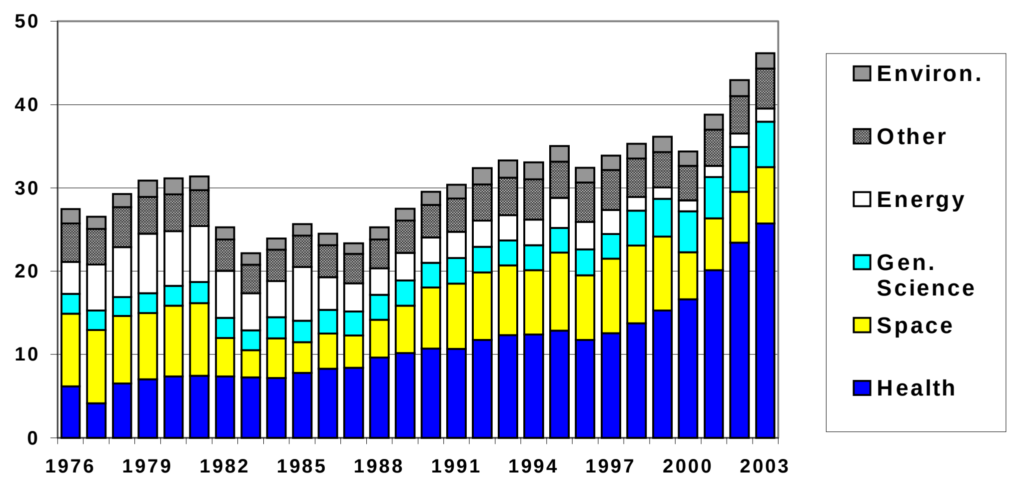


DOE's defense R&D is a relatively small part of the defense R&D portfolio. DOE funds R&D related to the U.S. nuclear weapons stockpile. After a steep post–Cold War drop, DOE defense R&D has been increasing in recent years as the United States has shifted its nuclear weapons strategy from a reliance on nuclear testing to science-based simulations as the best way to ensure the safety and reliability of the U.S. nuclear weapons stockpile. This has required large new investments in scientific facilities; advanced computer simulation research; and fundamental research in fusion, physics, and optics.

This leaves only a small part of the defense R&D portfolio in the so-called "S&T" category, which encompasses DOD basic research, applied research, and technology development not tied to specific weapons systems ("6.1" through "6.3" categories in DOD terminology). These programs contribute to a broad knowledge base with potential applications to a wide variety of military and civilian uses. DOD's S&T investment provides the science and technology knowledge to meet future DOD defense requirements and also trains the next generation of U.S. scientists and engineers in a host of fields, such as mathematics, computer sciences, and engineering. From its S&T budget, DOD supports 12.8 percent of all federal basic and applied research, and is a key sponsor of several science and engineering (S&E) disciplines. DOD supports 35 percent of all federal research in the computer sciences and nearly 40 percent of all engineering research, as well as significant shares of research in oceanography and mathematics (NSF, 2002b).[3]

Investment in DOD S&T reached $10 billion in today's dollars this year (FY 2002) for the first time since the early 1990s. For most of the 1990s, DOD S&T declined in post–Cold War defense cuts. Last September, DOD endorsed (in its Quadrennial Defense Review) the goal of spending 3 percent of the total DOD budget on S&T, and DOD's FY 2002 appropriations met this goal. The FY 2003 budget, however, would see S&T fall to 2.6 percent of the budget, with cuts in DOD basic and applied research programs.

Figure 1-3. Trends in Nondefense R&D by Function: FY 1976–2003
(outlays in billions of constant FY 2002 dollars)

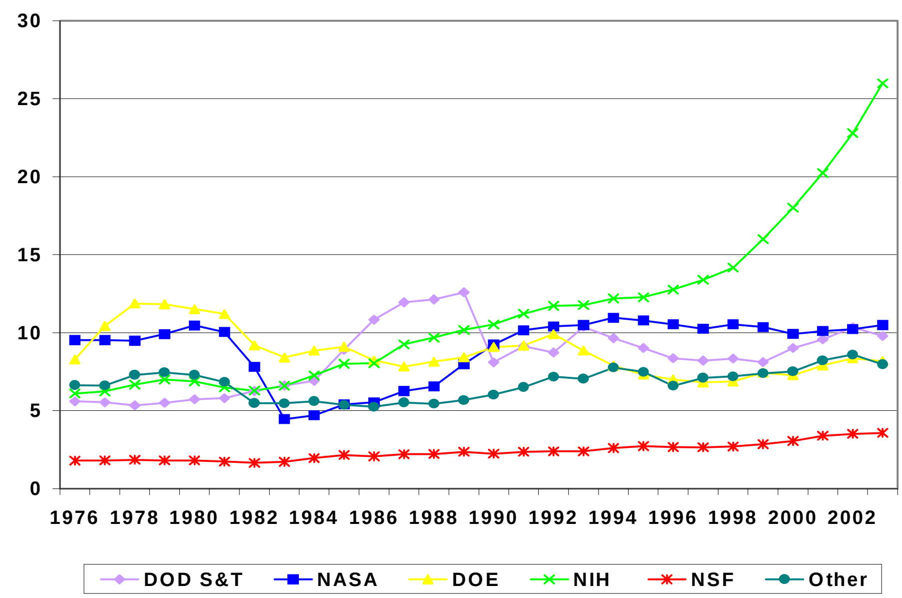


Source: AAAS, based on OMB Historical Tables. Constant dollar conversions based on OMB's Gross Domestic Product deflators. Excludes R&D facilities.
Some Energy programs shifted to General Science beginning in FY 1998. MARCH '02 © 2002 AAAS

[3]DOD's share of federal oceanography research support is 29.5 percent, for mathematics research 15.1 percent. Data are for FY 2000.

For nondefense R&D, the past three decades have seen a series of fluctuations reflecting changes in national goals and priorities, as shown in Figure 1-3. Energy R&D was a high priority in the 1970s because of the energy shocks and oil crises of the era; space R&D declined in priority from the 1970s to the early 1980s, until the shuttle Challenger disaster and subsequent International Space Station project increased its priority in the national R&D portfolio. Health R&D, meanwhile, has shown practically uninterrupted growth over these years and now represents the largest single share of the civilian R&D portfolio. A large share of the proposed FY 2003 increase in health R&D is devoted to bioterrorism research, part of a shift toward the goals of national security and counterterrorism in the FY 2003 budget. "General science" R&D, or science purely for science's sake, is a relatively small part of the U.S. federal R&D portfolio. And although much of the federal R&D investment, and especially the basic research investment, is purportedly for the purpose of laying the knowledge base for future U.S. economic growth, very little of the federal R&D investment is classified as "commerce" R&D (in Figure 1-3, it is one of many missions in the 'other' category). Thus only a small part of the federal R&D portfolio is funded with economic growth as an explicit goal.

Figure 1-4. Trends in Federal R&D by Agency: FY 1976–2003
(budget authority in billions of constant FY 2002 dollars)



Source: AAAS Reports I-XXVII based on OMB and agency R&D budget data. Includes conduct of R&D and R&D facilities. Excludes DOD weapons systems development. Constant dollar conversions based on OMB's GDP deflators. MARCH '02 © AAAS

As Figure 1-3 shows, the composition of the federal R&D portfolio is capable of changing rapidly and substantially to reflect changing national needs. These changing priorities translate to changing agency R&D budgets, as shown in Figure 1-4 (also see Appendix I, Table 3). The figure shows both nondefense and defense R&D (it excludes DOD weapons development because of its large size; the DOD line includes DOD S&T only). In recent years, the growing priority attached to health has led to a steady increase in R&D funding for the National Institutes of Health (NIH), part of the Department of Health and Human Services (DHHS), growth that has accelerated since 1997 because of a bipartisan campaign to double the NIH budget between FY 1998 and FY 2003. The National Science Foundation (NSF) has also seen budget growth in recent years and would be at an all-time high in FY 2003.

The FY 2003 proposed budget would continue the agency trends of recent years. The FY 2003 R&D request of $112.0 billion in budget authority would be $8.9 billion or 8.6 percent more than the current FY 2002 funding level. The proposed increases for DOD weapons development ($5.6 billion) and NIH R&D ($3.7 billion) would make up more than the entire increase, leaving all other R&D funding agencies combined with less money than in FY 2002. Four of the eleven largest R&D funding agencies would see their R&D decline in FY 2003, five if only DOD S&T (excluding development, testing, and evaluation of weapons systems) is included.

Over the past decade, the top five R&D funding agencies, DOD, DHHS, NASA, DOE, and NSF, have accounted for more than 90 percent of the total federal R&D budget. DOD and NIH have commanded the largest shares of each year's R&D budget; DOD (including weapons development) has steadily hovered around the 50 percent mark, while NIH now accounts for nearly a quarter of federal R&D activity; as Figure 1-4 shows, NIH's share has been expanding rapidly. In the meantime, other R&D funding agencies would face FY 2003 with essentially the same levels of R&D funding as over the past decade, despite steady growth in the U.S. population, the U.S. economy, and the federal budget during this period.

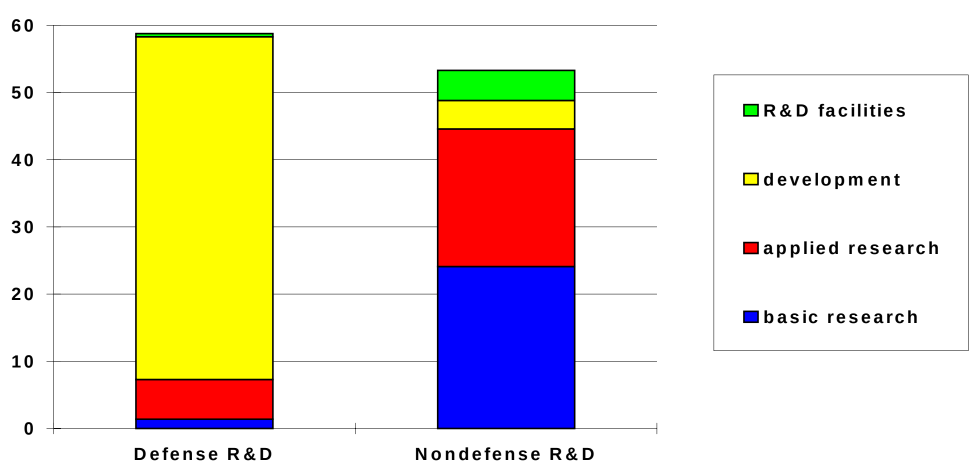
Another way to examine the federal R&D portfolio is by character of work. Statistics on federally funded R&D generally make distinctions among the character of work categories of basic research, applied research, development, and R&D facilities and capital equipment. (See Definitions of "Research and Development" and Other Terms.)

The data shown in Appendix I, Table 4 represent agencies' best attempts to classify character of work within their R&D portfolios. Except for DOD, which as noted above has separate budget categories for basic research ("6.1"), applied research ("6.2"), and various stages of development ("6.3" through "6.7"), the data reported here are imprecise and reflect the agencies' judgments as to how their R&D fits into the definitions. Appendix I, Table 4 shows that basic research would climb 7.9 percent or $1.9 billion to an all-time high of $25.5 billion in the Bush Administration's FY 2003 budget, primarily because of a 9.0 percent requested increase for basic research in the NIH budget. NIH would provide the majority (56 percent) of federal basic research. Basic research excluding NIH would rise by 6.5 percent to $11.1 billion in FY 2003.

The total federal investment in research (basic and applied research) would increase 6.5 percent to $51.9 billion (see Appendix I, Table 4), but excluding a large increase for NIH, all other federal research would fall 0.2 percent to $23.8 billion. NIH's applied research would increase by a particularly large $2.0 billion, or 20.4 percent, outpacing growth in basic research, because the FY 2003 high-priority areas of cancer and counter-bioterrorism involve significant work in applied rather than basic fields.[4] Development would increase 11.8 percent to $55.2 billion in FY 2003 because of an enormous infusion of funds for DOD's development of weapons systems, including national missile defenses, new fighter planes, and an array of other expensive future weapons systems.

The character of work is quite different in defense and nondefense R&D, a point illustrated in Figure 1-5 and Appendix I, Table 4. Development would be by far the largest component of defense R&D, accounting for 87 percent of the FY 2003 total, while applied research would be 10 percent and basic research would be only 2 percent. In nondefense R&D, by contrast, basic research would be the largest category at 45 percent, with development at only 8 percent and applied research at 38 percent. A major reason for the difference between the character of defense and nondefense R&D is that development in DOD includes testing and evaluation of weapons systems. These activities are extremely expensive compared to other types of R&D. The remainder of the R&D budget for FY 2003 consists of R&D facilities and capital equipment costs, which make up 8 percent of nondefense R&D and only 1 percent of defense R&D. The nondefense ratio is up sharply from previous years because NASA has recently reclassified the International Space Station from a mostly development project to a mostly facilities construction project.

Figure 1-5. Character of Defense and Nondefense R&D FY 2003 Budget
(budget authority in billions of dollars)



Source: AAAS, based on OMB R&D budget data for FY 2003 and agency budget justifications. Defense R&D = DOD + DOE defense programs. FY 2003 data are President's request.
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The composition of the federal R&D portfolio has been shifting dramatically over the years, primarily because of declines in defense development in the post–Cold War era and increases in NIH support of basic research. At the height of the Cold War, development (mostly in DOD)

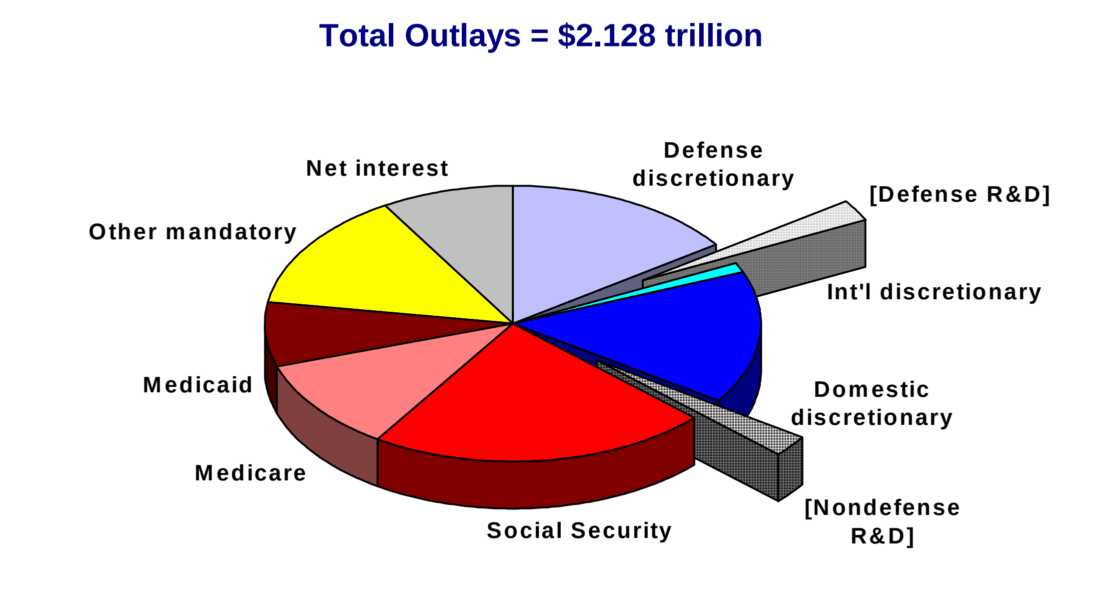
[4]The explanation of PCAST Issue 3 on R&D Balance provides data on the federal research portfolio by science and engineering field; development and R&D facilities are not classified by field.

made up nearly two-thirds of the federal R&D portfolio, but now makes up only 49 percent. Basic research, meanwhile, has steadily expanded its share of the federal R&D portfolio, from 14 percent in FY 1980 to 17 percent in FY 1990 to 23 percent in FY 2003.

R&D Within the Federal Budget

Federal R&D expenditures represent 5.0 percent of the overall proposed $2.1 trillion budget for FY 2003 and 13.6 percent of the discretionary (appropriated) portion of that budget (OMB, 2002; AAAS, 2002a). As Figure 1-6 shows, discretionary spending, the part of the budget that Congress and the President control every year, makes up only one-third of the total federal budget. The remaining two-thirds of the annual federal budget is made up of entitlement programs (e.g., social security, veterans benefits, medicare, etc.) and other mandatory spending, all of which is permanently authorized in law and therefore does not require annual approval by Congress. Because nearly all R&D programs are within the discretionary one-third of the budget, spending decisions on R&D programs must be made annually within the discretionary appropriations process, and R&D programs must compete annually for resources against all other discretionary programs. Discretionary spending is customarily divided into defense and nondefense components (the nondefense component is sometimes divided into a small international component and a larger domestic component); as Figure 1-6 shows, defense and nondefense discretionary are roughly equal in size.

Figure 1-6. Composition of the Proposed FY 2003 Budget



Note: Projected Unified deficit is $80 billion. Defense and nondefense R&D are components of defense and domestic discretionary, respectively.
Source: AAAS, based on *Budget of the United States Government FY 2003.*
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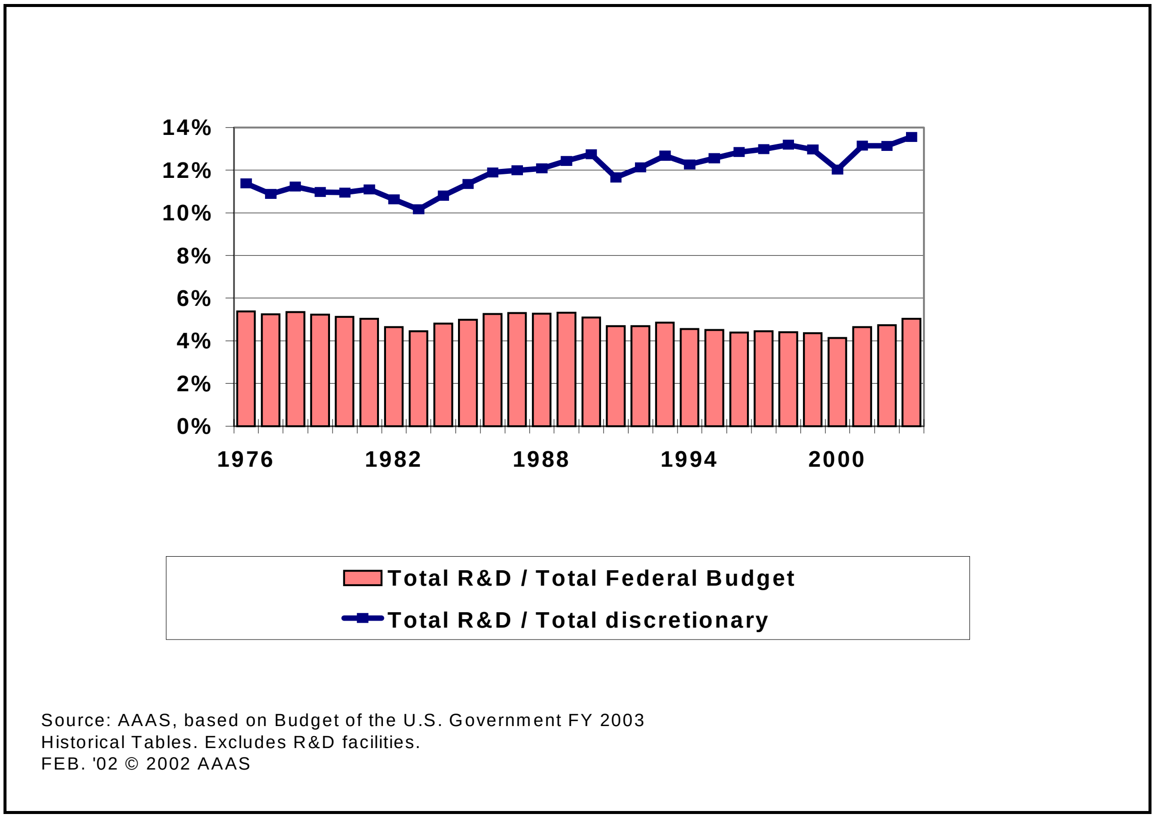
Defense and nondefense R&D make up nearly one out of every seven dollars of defense and nondefense discretionary spending, respectively, a ratio that has actually increased slightly over time as defense R&D has increased as a share of the defense budget (see Figure 1-7). On the whole, trends in R&D funding have closely followed trends in discretionary spending. Over the past 20 years, federal R&D has consistently remained within one or two percentage points of 12 percent of all discretionary spending. Growth in overall discretionary spending over the past several decades has allowed federal investment to grow in many areas, including R&D.

As a share of the total federal budget, however, R&D has declined over time because discretionary spending has declined as a share of the federal budget. Because of automatic growth in spending on entitlement programs, such as Social Security, Medicare, and Medicaid, to account for growth in eligible populations, automatic cost-of-living increases, and medical inflation, mandatory programs have grown from less than half of the federal budget in the 1970s to two-thirds in the 2000s. As a result, R&D has declined slightly as a share of the federal budget, as shown in Figure 1-7. In particular, R&D has declined from 5.4 percent of the budget in FY 1976 to 5.0 percent in FY 2003.

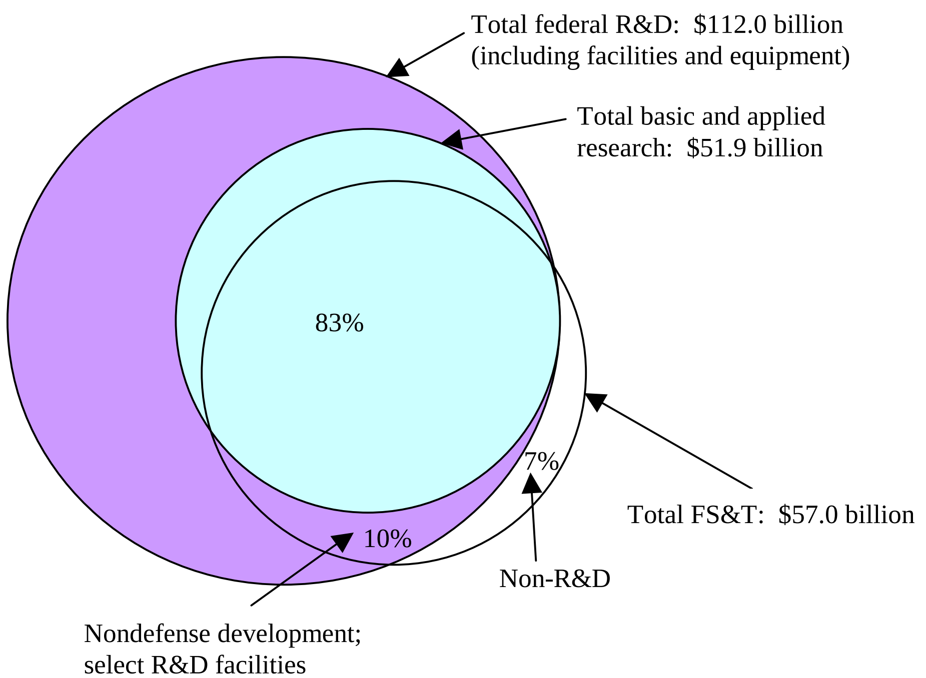
Figure 1-7. R&D as Percent of Discretionary Spending and All Federal Spending: FY 1976–2003
(percent of outlays)



Although the federal government's budget proposals generally contain a section devoted to R&D and several tables and charts summarizing proposed and actual R&D expenditures, it is important to recognize that unlike many other nations, the U.S. does not have an "R&D budget" and no single coordinated authority to set priorities or allocate resources for R&D within the budget.

Expenditures for R&D programs are regular budget items. They are contained, along with other types of expenditures, within the budgets of 23 federal departments and independent agencies (the exact number varies from year to year as some small agency programs are created or eliminated). For some of these agencies, such as the NSF, NASA, and NIH, R&D is a dominant activity. For others, such as the Department of Housing and Urban Development (HUD), it is a small part of a larger set of programs. Some R&D programs are line items within the budget and are relatively easy to identify as R&D. Others are included within larger line items and are more difficult to find.

Figure 1-8. Comparison of R&D, Research, and FS&T in the Proposed FY 2003 Budget



Percentages represent shares of the FS&T budget for FY 2003. Update of chart in NSF, Science and Engineering Indicators 2002. Source: AAAS analysis of R&D and FS&T in the FY 2003 budget (see notes for Appendix I Table 5).

In an attempt to make it easier to track the federal investment in science and technology through the federal budget process and also to establish a measure of federal S&T investments that excludes weapons systems development, the Office of Management and Budget (OMB) has developed the "Federal Science and Technology Budget" (FS&T) concept in recent years. (See also the "Definitions" section at the beginning of this report.) Unlike the established definitions for R&D, there is no definition for FS&T. The FS&T portfolio is a set of federal programs selected by OMB that consists of easily identified budget line items, that approximates as closely as possible the federal basic and applied research portfolio and nondefense development. The current FS&T budget also includes some non-R&D education and human resources programs and some R&D facilities investments and excludes DOD weapons systems development and some large facilities projects, such as the International Space Station. Appendix I, Table 5 compares FS&T with total R&D by agency. Because it excludes DOD weapons systems development and DOE defense R&D, there is a large difference between R&D and FS&T on the defense side; but nondefense R&D and nondefense FS&T match fairly closely. As Figure 1-8 shows, although FS&T is constructed differently than R&D, there is a great deal of overlap with the federal research portfolio. However, because FS&T contains fewer agencies than R&D and contains whole budget accounts instead of only the R&D components of programs, it is easier to track than R&D.

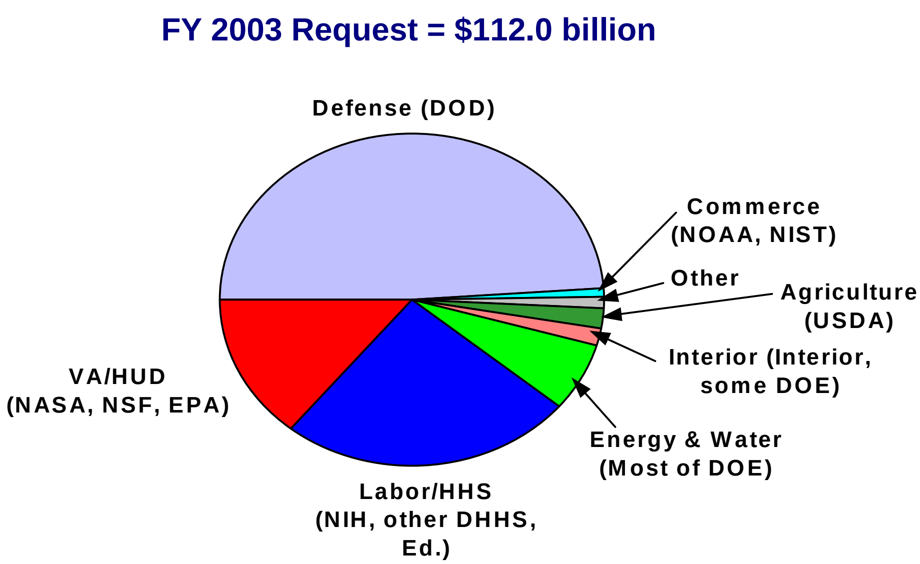
The OMB, in consultation with the Office of Science and Technology Policy (OSTP; both are within the Executive Office of the President), has overall responsibility for preparation of the President's budget and is able to provide some coordination between the scattered programs of the federal R&D portfolio, although OMB is hampered by the fact that R&D funding agencies are treated individually by its different divisions (organized along mission lines) in the budget formulation and review process. Some coordination also takes place under the National Science and Technology Council (NSTC), an interagency body comprised of cabinet officers and the President, whose day-to-day functions come under OSTP jurisdiction. These organizations help to coordinate several interagency initiatives in S&T that have grown in funding over the years, including the National Nanotechnology Initiative (NNI), the National Information Technology Research and Development (NITRD) initiative, and the U.S. Global Change Research Program (USGCRP). Funding for these initiatives is shown in Appendix I, Table 6.

Although the federal counterterrorism R&D investment is a multiagency effort for which budget data are collected (an estimated $1.5 billion investment in FY 2002 according to an AAAS analysis), it is not yet a multiagency initiative with its own coordinating mechanisms. At present, each agency's counterterrorism R&D program is formulated separately and is only informally coordinated through OMB (AAAS, 2002b). The newly created Office of Homeland Security may, in cooperation with OMB and OSTP, be in a position in the future to coordinate agencies' counterterrorism R&D investments and, in the process, to coordinate R&D with other counterterrorism spending. Appendix I, Table 7 shows the federal counterterrorism R&D investment by agency. Most, though not all, of this R&D investment would come under the purview of the proposed Department of Homeland Security under the Bush Administration proposal.

Even the modest level of coordination in R&D in the executive branch is not matched by Congress. Congressional treatment of R&D, as with most other aspects of congressional budget and policymaking, is characterized by fragmentation and diffusion of power. R&D programs are considered at two main levels in Congress: authorizations and appropriations. Authorizing committees (such as the House Science Committee and the Senate Committee on Health, Education, Labor, and Pensions) develop special expertise in the programs they oversee and review the substance of these programs. However, the legislation they prepare does not directly result in spending but only provides guidance and recommends appropriations ceilings.

For discretionary programs, including R&D, the power to write the legislation that provides actual spending authority resides in the Appropriations Committees of the House and Senate. These committees are each divided into 13 subcommittees, each of which is responsible for a bill that controls one portion of the budget. Figure 1-9 shows the distribution of R&D funds among these appropriations subcommittees; each subcommittee produces its appropriations bill separately from the others, and each bill is usually approved by Congress and signed into law separately (also see Appendix I, Table 8).

Figure 1-9. R&D Funding by Appropriations Subcommittee



Source: AAAS, based on estimates of R&D in FY 2003 budget.
Includes conduct of R&D and R&D facilities.
Other = Transportation; Foreign Operations; Treasury-Postal
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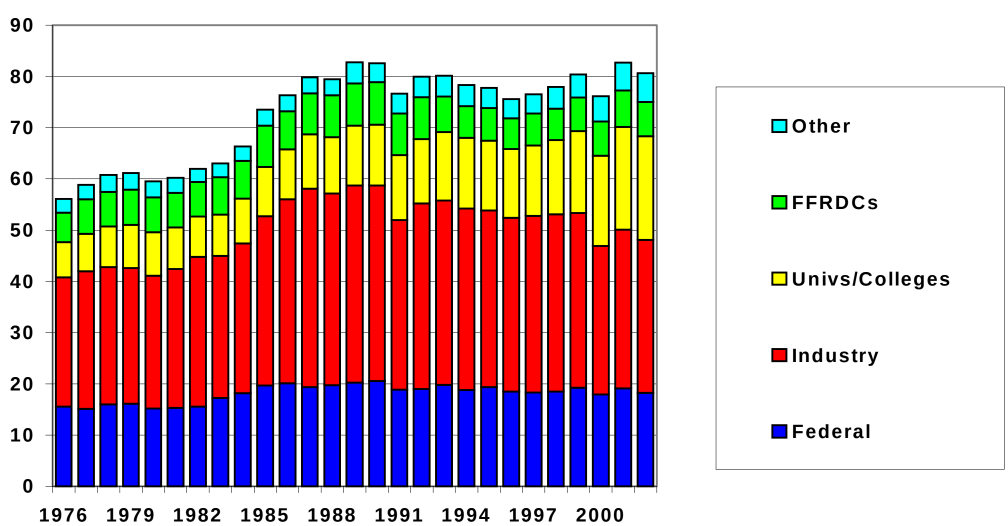
The division of the budget into 13 appropriations bills limits the extent to which it is possible to coordinate or trade off increases and decreases in agency R&D budgets in the congressional process. For example, three R&D agencies—NSF, NASA, and the Environmental Protection Agency (EPA)—come under the jurisdiction of the Subcommittee on Veterans' Affairs, Housing and Urban Development, and Independent Agencies. NIH appropriations are decided by the Labor, Health and Human Services, and Education subcommittee. This means, for example, that money used for the large increase in NIH's budget in FY 2002 did not come from the same pot of money that funds NSF and NASA. Unlike industrial R&D budgets, then, which are usually allocated in a central manner allowing for trade-offs between priorities within the R&D portfolio and against other priorities, the federal R&D investment is decided in a highly decentralized and uncoordinated manner that makes trade-offs and priority-setting within the portfolio extremely difficult. Conversely, the decentralized decision-making process tends to inhibit sudden swings in R&D funding and smoothes out year-to-year changes in the composition of the federal portfolio.

Federal R&D by Performer

Although the federal government maintains several hundred laboratories around the country, only 23 percent of federally supported R&D in FY 2002 is actually carried out in these laboratories (see Figure 1-10). The largest share of federally funded R&D is performed by industrial firms under contracts. This total has fluctuated greatly over time because nearly all DOD development is performed by military contractor firms; as noted earlier, funding for this category has been volatile because of changing military development priorities. Industrial firms also perform a large portion of DOD "S&T" (i.e., DoD's R&D categories 6.1-6.3) and NASA R&D. A significant amount of R&D is performed under federal grants in universities and colleges, as well as other nonprofit institutions, including federally funded research and development centers (FFRDCs) operated by contractors, such as the Department of Energy's Argonne National Laboratory in Illinois, which is operated by the University of Chicago. As Figure 1-11 shows, the mix of R&D performers varies greatly by agency because of agencies' differing missions and the flexibility each agency has to award its R&D funds to the best performer for the task. From the chart, it is clear that NIH is the dominant funding source for R&D performed by universities and colleges; NIH now provides nearly two-thirds of all federal R&D funds to universities and colleges. Because of steady budget growth at NIH over the past several decades, total federal R&D performed by universities and colleges has grown steadily for the past few decades even as the performance of R&D by federal laboratories (which figure heavily in the R&D portfolios of non-NIH agencies) has declined and as performance of R&D by industrial firms has fluctuated.

Figure 1-10. Federal R&D Funding by Performer: FY 1976–2002
(obligations in billions of constant FY 2002 dollars)



Source: AAAS, based on NSF, Federal Funds for Research and Development Fiscal Years 2000, 2001, and 2002 and Federal Funds Historical Tables, 2002. FY 2001 and 2002 data are preliminary. Excludes R&D facilities funding.
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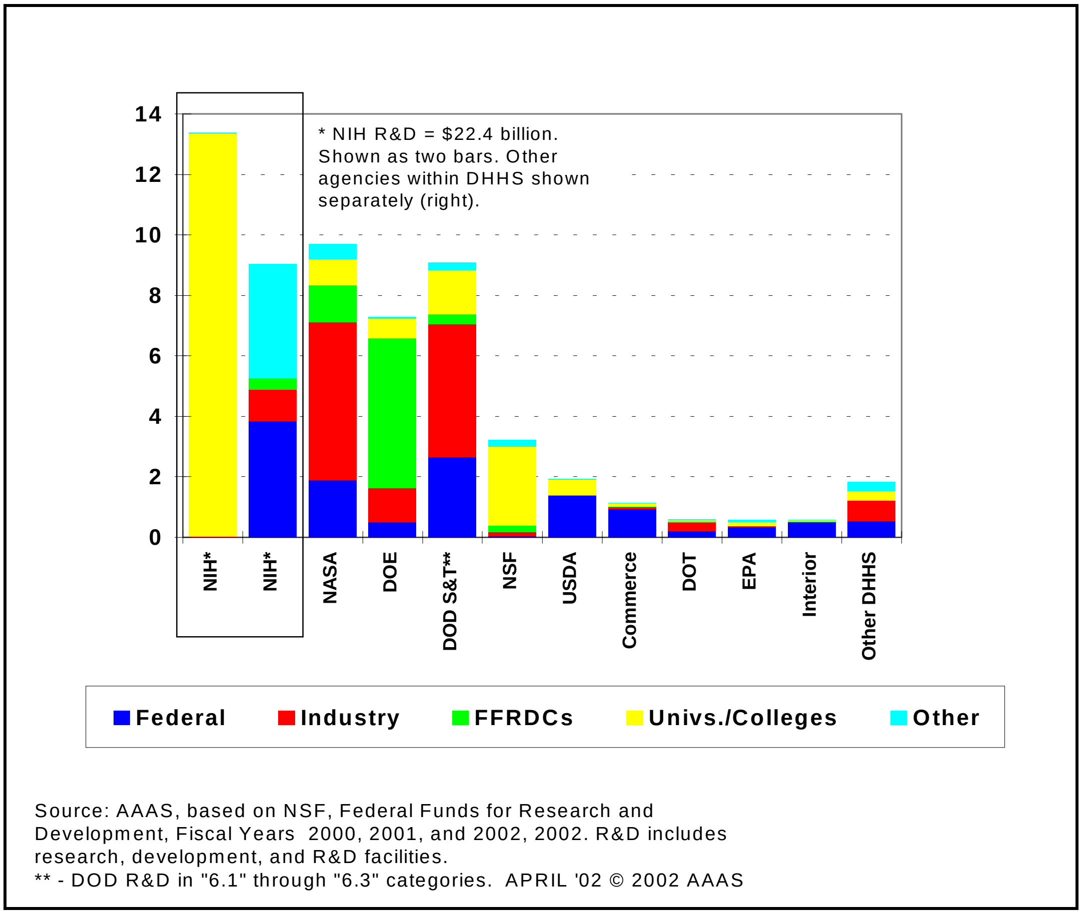
Figure 1-11. Federal R&D by Performer at Selected Agencies
(billions of dollars of FY 2002 obligations—preliminary)



In summary, there has been overall growth in the federal R&D portfolio over the past few decades, although growth has not always been steady. In the mission-oriented federal R&D system, changing national priorities in areas such as health and defense have resulted in shifts in the composition of the federal R&D portfolio; in recent years, health and defense have grown significantly to become the largest missions in the R&D portfolio. R&D is a small but significant part of the federal budget, and is therefore responsive to larger trends in the federal budget; in particular, the overall federal investment in federal R&D has closely followed trends in the discretionary part of the federal budget.

Although it is common to talk about a federal R&D budget, R&D programs are actually scattered among 26 different federal agencies, which are handled individually in the congressional and executive budget processes, with only limited coordination because of the decentralized nature of the federal budget process. Federal R&D is also performed by a diverse collection of R&D performers, and the mix of performers varies by agency depending on the agency's R&D needs.

CHAPTER 2

It was clear to PCAST from the outset that any review of the federal R&D funding needed to be addressed in the context of total U.S. R&D funding, including private sector R&D funding as well as that of the states, in order to judge the full impact of the federal government's investment and its effects on the national well-being. PCAST raised the following issues:

> Identify major changes in private-sector, state and other major non-federal R&D spending, since 1975. Account for changes in the overall size of these R&D portfolios as well as their internal composition and discuss possible reasons for such changes.

To help understand these issues, PCAST asked for data on the major changes in private sector R&D, state R&D, and other major non-federal R&D efforts.[5]

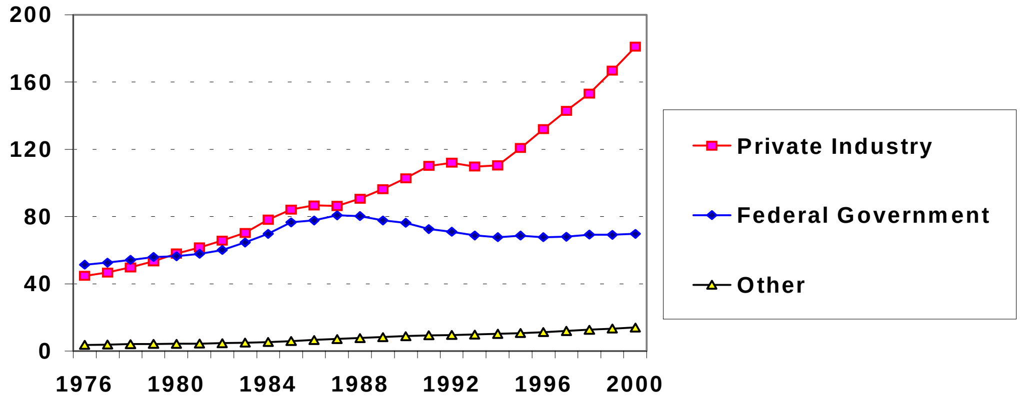
Trends in Total U.S. R&D

The total U.S. R&D portfolio (private and public investments) combined now exceeds $250 billion a year, making the United States by far the largest investor in R&D in the world. Although the R&D investments of other nations, especially those in Asia, have grown faster than U.S. R&D investments in recent decades, the United States still accounts for 40 percent of global R&D (OECD, 2001).

Total U.S. R&D has grown from $100 billion (in 2000 dollars) in 1976 to $265 billion in 2000 (also in 2000 dollars), with further increases expected in 2001 and 2002 when these data become available. Within this growth, there has been a remarkable shift in the composition of total U.S. R&D, as shown in Figure 2-1 (also see Appendix I, Table 9). In the 1970s, the federal government was the dominant supporter of R&D in the United States as it had been for the entire post–World War II era, while U.S. industrial firms were steadily but slowly increasing their investments in privately funded R&D. In 1980, however, industry support of R&D exceeded federal support for the first time because of stagnating federal support combined with accelerating growth in industry support. Since then, industry support of R&D has grown steadily and dramatically, except during economic slowdowns, but federal support of R&D has stagnated or declined in real terms after peaking in the mid-1980s as a result of post–Cold War cutbacks, mostly in defense R&D. (Recent budgets for federal R&D in fiscal years 2000 and later, which are still being spent in the U.S. R&D system and therefore do not show up yet in these figures, promise increases above the rate of inflation).

[5] AAAS began collecting and analyzing data on federal R&D spending in FY 1976. The information presented in this chapter is based on the AAAS data, and therefore includes FY 1976 through FY 2003.

Figure 2-1. U.S. R&D Funding by Source: 1976–2000
(expenditures in billions of constant FY 2000 dollars)



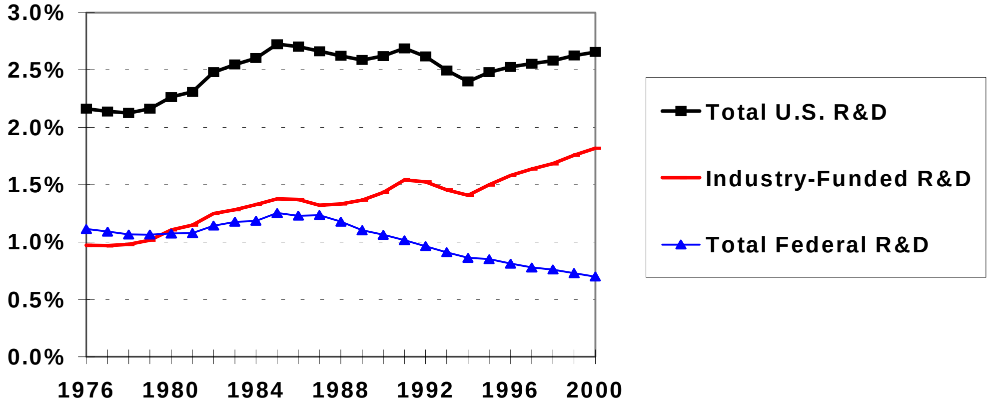
NOTE: "Other" includes R&D funding from nonprofit institutions, state and local governments, and colleges and universities with their own funds.

Source: AAAS, based on NSF, *National Patterns of R&D Resources :2000 Data Update* (Data for 2000 are preliminary.) Excludes R&D facilities. MARCH '01 © 2001 AAAS

U.S. industry investments in R&D have never been higher both in dollar terms or as a share of the economy. Industrial firms today fund two-thirds of total U.S. R&D, while the federal government share is just 26 percent. Industry is expanding its R&D investments far faster than the growth rate of the economy as a whole, as shown in Figure 2-2 (also see Appendix I, Table 10). In just the past 25 years, industry R&D as a percentage of the U.S. economy has nearly doubled, from just under 1 percent of GDP to nearly 2 percent. U.S. industry has thus become more R&D intensive. Much of this growth happened in the 1990s, when a long economic boom encouraged U.S. firms to invest more in R&D; historically, industry R&D has tended to increase during economic expansions and level off during recessions. But industry investments in R&D are at historical highs because of other factors as well, including the increasing importance in the U.S. economy of high-technology industries that rely heavily on R&D, such as the biotechnology and information technology industries. R&D investments have also increased in traditional manufacturing industries and in service industries, such as software, as innovation and technology become increasingly important sources of competitive advantage (NSF, 2002c).

Altogether, including the R&D that industrial firms support with their own funds and that which is performed under government contracts, industrial firms performed 75 percent of total U.S. R&D in 2000 (NSF, 2001b).

Figure 2-2. U.S. R&D as Percent of Gross Domestic Product
(Total, Industrial, and Federal R&D—1976–2000)



Source: AAAS, based on NSF, *National Patterns of R&D Resources,:2000 Data Update*.
2000 data are preliminary. R&D funded by other sources (universities, nonprofits, etc.) included in Total U.S. R&D. Includes defense and nondefense R&D. Excludes R&D facilities. MARCH '01 © 2001 AAAS

U.S. federal government policy affects industry investment in R&D in several ways. For example, the government's role in promoting stable economic growth can provide a favorable investment climate for industrial firms. The government's role in securing competitive domestic and international markets can expand the opportunities for industry to benefit from its R&D investments. The U.S. patent system provides incentives to inventors not only to disclose their inventions, but to profit from their use. The Bayh-Dole Act, passed by Congress in 1980, provides a strong incentive for commercial development by conferring ownership of patent rights to universities, small businesses, and nonprofit organizations. The Stevenson-Wydler Technology Innovation Act of 1980 gives industry access to federal laboratories and their specialized facilities, allows the use of federally developed technology for profit-making ventures, and makes technology transfer to industry and states a mission of all federal laboratories.

One government policy that directly affects industrial R&D is the Research and Experimentation (R&E) Tax Credit. This tax credit, which allows companies to deduct a portion of additional investments in R&D above a certain base amount from corporate income taxes, provides incentives for some companies to expand their R&D investments. The R&E Tax Credit, however, has only been approved for multiyear increments during its 20-year history and has periodically expired. It is currently scheduled to expire again in 2004; making the credit permanent would allow companies to plan R&D investments, which by their nature are multiyear and forward-looking, in a more certain planning environment. Proposals to extend the tax credit permanently have faltered in the past because of the cost: The credit reduces tax revenues by approximately $5 billion a year (OMB, 2002).[6] The Bush Administration, in its FY 2003 budget, has proposed making the tax credit permanent.

Industrial R&D and Government R&D in the U.S. R&D Enterprise

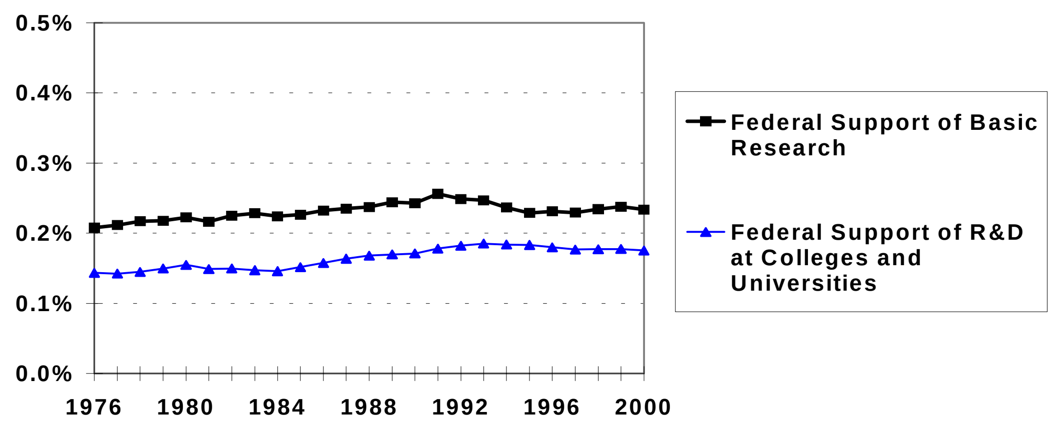
The federal government, by contrast, has seen its R&D investments steadily decline as a share of the U.S. economy. Federal R&D has declined in dollar terms in many years; even in years when the investment has increased, the increases have barely kept pace with inflation and have fallen far behind the growth rate of the U.S. economy. As shown in Figure 2-2, federal R&D as a percentage of GDP has shrunk steadily to 0.7 percent of GDP in 2000, bringing the federal investment down to levels not seen since the early 1950s. Although recent budget increases for federal R&D in FY 2001 and 2002 are significant, they would not materially alter these long-term trends.

These divergent trends for federal and industry R&D are important because of the very different character and missions of these two sources of U.S. R&D funds. They are not substitutes for one another. Despite its now-modest share of total U.S. R&D funding, the federal government's role is critical to the U.S. science and technology enterprise. The federal government supports a majority of the nation's basic research and 58 percent of the R&D performed in U.S. universities and colleges (NSF, 2001b; NSF 2002d). Basic research is the primary source of the new knowledge that ultimately drives the innovation process. At the same time, federally funded R&D at universities and colleges plays a key role in educating the next generation of scientists and engineers and a technically skilled workforce (see PCAST Issue 4 on Education, Workforce and Research Outputs for a discussion about trends in graduate student enrollment and number of doctorates awarded, and federally funded research in science, engineering, and health fields). Research grants to universities and colleges often provide graduate stipends in the sciences and engineering and also provide research experiences essential to graduate learning in these fields. Federal support for basic research and academic R&D, however, has barely kept pace with economic growth in recent years and remains small in comparison to the U.S. economy, as shown in Figure 2-3.

Federal applied research and development programs also provide support for key government missions, such as improving the nation's health, exploring space, and providing national security. Although industrial firms' R&D efforts are more important than ever in determining near-term U.S. economic competitiveness, progress toward technology frontiers, and the overall health of the increasingly technology-based U.S. economy, industry R&D is heavily oriented toward company-specific technology problems and is focused more on development than on the kind of basic research that will provide the foundation for future scientific breakthroughs.

[6] There is another, permanent provision in the tax code that allows companies to deduct certain R&D expenses from taxable income; this provision costs the government $2 billion in revenues a year.

Figure 2-3. Federal Support of Basic Research and Academic R&D as Percent of Gross Domestic Product: 1976–2000



Source: AAAS, based on NSF, *National Patterns of R&D Resources, 2000* . 2000 data are preliminary. Includes defense and nondefense R&D. Excludes R&D facilities.
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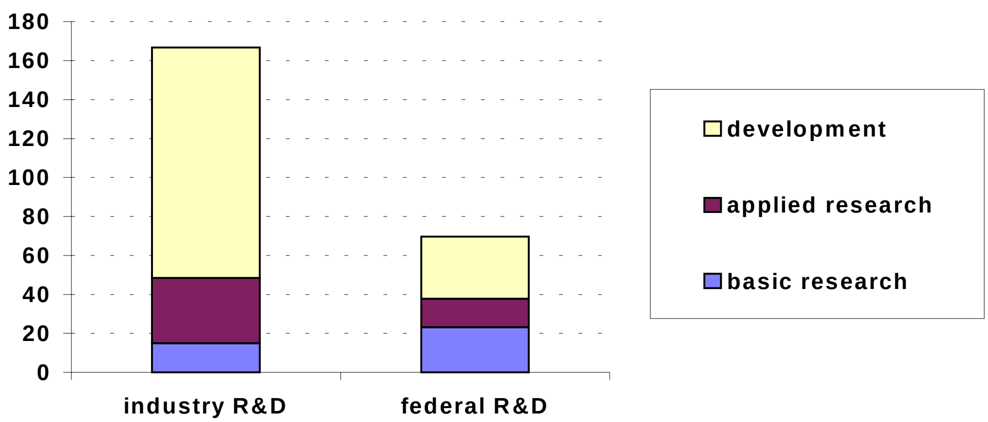
Figure 2-4 shows that industry R&D consists largely of development, with less for applied research and even less for basic research. The federal R&D portfolio, by contrast, is more evenly divided among basic research, applied research, and development, although even here development is dominant because the federal government funds nearly all defense development for new weapons systems. The federal government funds the majority of the long-term, fundamental basic research in the United States and some applied research as it relates to national missions, such as space and health. Industrial firms, by contrast, are overwhelmingly focused on the development of new products, with some applied research aimed at developing new technologies; industry also funds some basic research in areas in which fundamental knowledge can be turned relatively quickly into breakthrough products, such as biotechnology, or in areas in which large firms can afford to scan the horizon for future possibilities such as information technology. It is worth noting that in the 1990s both basic research and applied research in industry grew slightly faster than the industrial R&D portfolio as a whole, in a decade when the total portfolio expanded dramatically (see Figure 2-1). Despite robust growth, however, these two categories still make up small portions of the total industrial R&D portfolio.

Figure 2-4. Character of U.S. Industry and Federal R&D: 2000
(expenditures in billions of dollars)



Source: AAAS, based on NSF, *National Patterns of R&D Resources 2000.* Data for 2000 are preliminary. Excludes R&D facilities. MARCH '01 © 2001 AAAS

Other sources of funding include state and local governments, independent nonprofit institutions, and universities and colleges with their own funds (collectively "Other" in Figure 2-1 and Table 9). Although these sources of funds are small relative to federal and industry sources of funds, they have been growing rapidly and reached $14.0 billion in 2000, or 5.3 percent of the national total. Of this total, $6.0 billion represents R&D performed at universities and colleges with their own funds; mostly, these funds represent indirect support of R&D through state appropriations, R&D funding from universities' endowments, or funding through tuition and other forms of general revenues. In recent years, this source of funding has grown to nearly 20 percent of these institutions' total academic R&D portfolios as institutions' cost-sharing requirements on grants have grown, as institutions invest seed money in research ventures or infrastructure in the hopes of attracting other funding in the future, or as select institutions reinvest proceeds from intellectual property income on additional research. $5.8 billion of R&D funding comes from independent nonprofit institutions (other than universities and colleges) such as independent research institutions, research hospitals, think tanks, membership societies, and philanthropic foundations. A majority of these funds goes to R&D performed in nonprofits, but a significant portion ($2.2 billion) goes to universities and colleges, primarily to fund biomedical research. Although funding from this source grew dramatically in the 1990s, it is unclear how much of this growth was driven by tremendous growth in foundation endowments during the 1990s bull market and thus, until more recent data become available, it is unclear whether this growth will be sustained in the future. Finally, state governments funded $2.2 billion in R&D in 2000, almost entirely for support of specific R&D projects at universities and colleges, separate from general state higher education support. Although, state support grew in the 1990s, it grew far more slowly than industry, university, and nonprofit support. With state budgets under tremendous pressure in the last two years because of falling tax revenues, state support is expected to stagnate for the next few years.

In summary, there has been a profound shift in the balance between federal and private-sector R&D in the United States. In the last few decades, the party funding two-thirds of all U.S. R&D has gone from being the federal government to being the private sector. In real dollars, total U.S. R&D has hit all-time highs in the past few years led by surging industry investments in R&D. But increasing industry support of R&D cannot offset decreasing federal support because the two R&D portfolios are oriented toward different goals. Although funding from other sources has grown rapidly in recent years, their combined support is still small compared to that of the federal government and industry. Thus, strong support from both the federal government and the private sector is necessary for a strong U.S. science and engineering enterprise.

CHAPTER 3

The issue of balance among the fields of S&E has been a recurring topic of interest among executive branch and congressional policy makers, and has been discussed in previous reports (NAS, 1995; McGeary and Merril, 1999; STEP, 2001). PCAST was concerned about recent shifts in funding among the fields of S&E, and raised the following issues:

> Identify changes since 1975 in the balance of funding among the fields of science and engineering that constitute the federal R&D portfolio. Identify current trends in the balance of funding among these fields and explore the possible ramifications of such trends.

To address the issue of balance, PCAST asked for data on changes in the allocation of federal R&D funding among S&E fields and changes in agency funding of S&E over the last 25 years.[7]

Historical Trends in Funding of Science and Engineering Fields

From 1970 through 1975, federal funding of research was fairly flat, coinciding with the budget pressures of the Vietnam War and following the lunar landing. Although the total level of funding for research did not change significantly, there were significant shifts in the allocation of the funds among fields of S&E (Figure 3-1; also see Appendix I, Tables 11 and 12). Federal funding of engineering decreased 17 percent, and funding of the physical sciences decreased 13 percent, with physics experiencing a reduction of 20 percent (Figure 3-2; also see Appendix I, Tables 13 and 14). In contrast, federal support for the life sciences increased 28 percent, and environmental sciences increased 12 percent.

The life sciences, physical sciences, environmental sciences, and math and computer sciences experienced a period of growth between 1976 and 1980 (Figure 3-1). However, federal funding of the social sciences, engineering, and psychology was fairly flat during this time period.

During a period of recession in the early 1980s, several fields, including the life sciences, social sciences, and environmental sciences, experienced a decrease in funding (Figure 3-1). Decreases in the social sciences and environmental sciences were also a direct result of policy implemented by the Administration at the time. However, by 1983, most fields began experiencing increases in federal funding. Federal support for several fields increased significantly from 1981 to 1985: Mathematics and computer sciences increased 72 percent, driven largely by a 93 percent increase in computer sciences; psychology increased 31 percent; the life sciences increased 20 percent; and the physical sciences increased 15 percent (Figure 3-2). In contrast, federal funding of the social sciences experienced a decrease of 23 percent, and funding of engineering decreased 5 percent from a high in 1982. Although federal funding of the environmental sciences climbed 5 percent between 1981 and 1985, it was still 15 percent below the funding levels in 1980.

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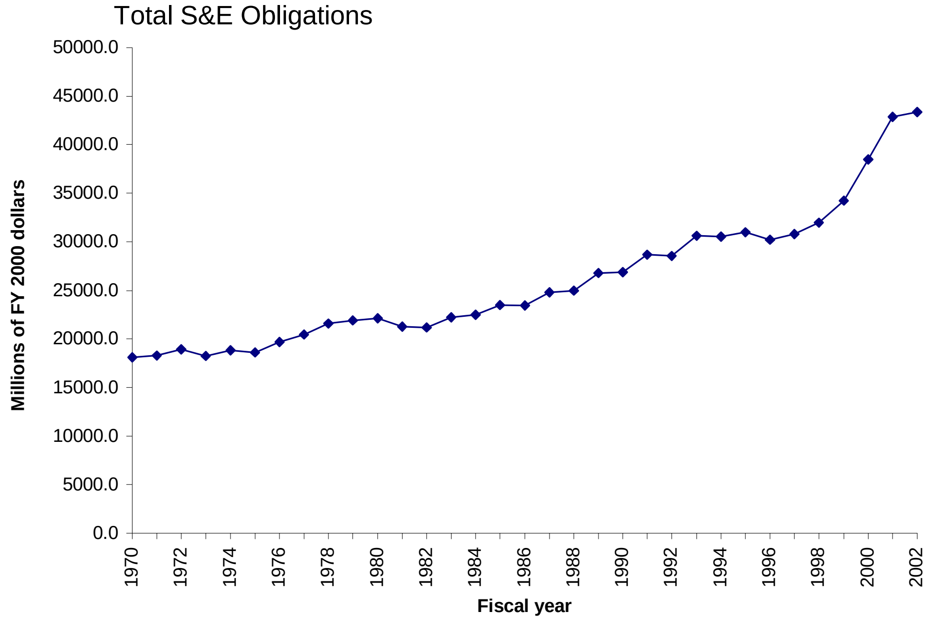
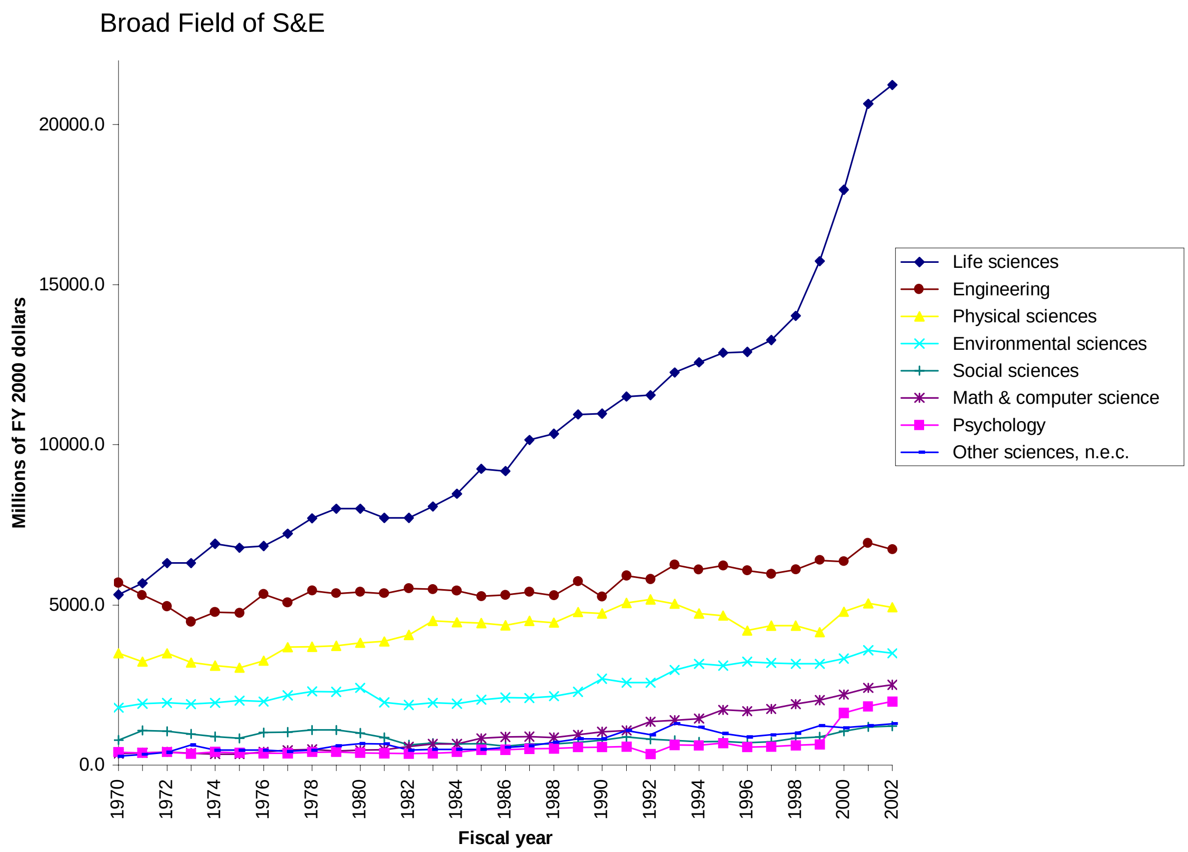
[7] Data on federal funding by field of S&E were available starting in 1970, when NSF began to ask federal agencies about their research allocations by fields of S&E in the Survey of Federal Funds for Research and Development. Therefore, the data presented in this chapter include FY 1970 through FY 2002, the latest year for which there is preliminary data. It is also important to note that the Survey only collects S&E field data for federal funding of basic research and applied research. It does not collect S&E field data for development or R&D plant funds.

Figure 3-1. Federal Obligations for Research, Total and by Broad Field: FY 1970–2002 (constant FY 2000 dollars)





NOTE: FY 2001 and 2002 data are preliminary.

SOURCE: RAND, based on NSF, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds: Detailed Historical Tables: Fiscal Years 1951–2001.

Figure 3-2. Federal Obligations for each Broad Field of S&E and its Component Detailed Fields: FY 1970–2002
(constant FY 2000 dollars)

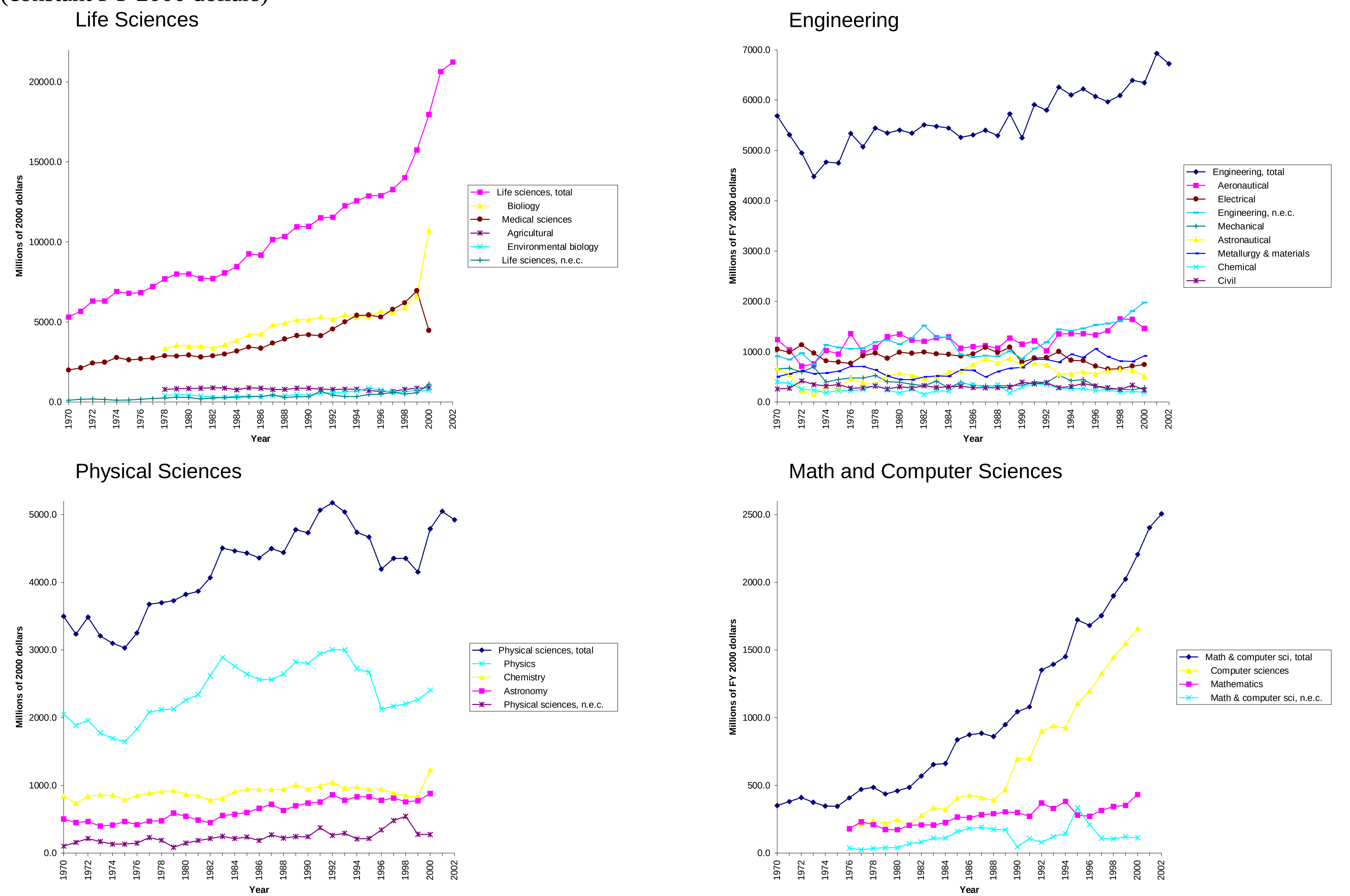
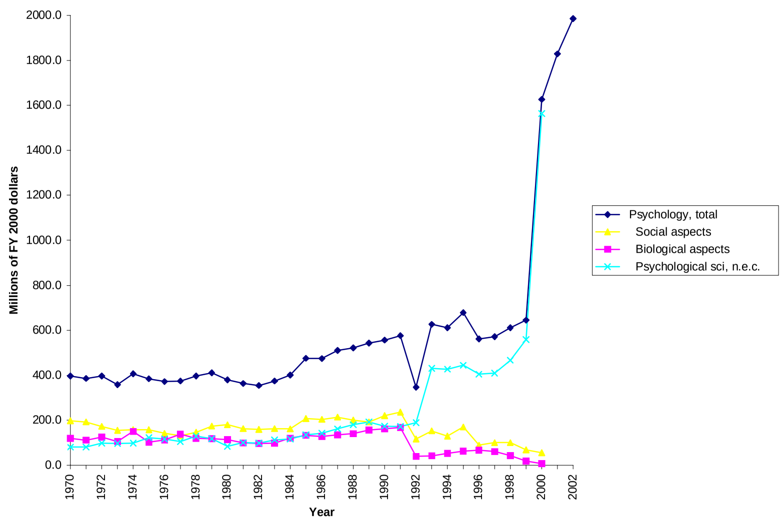
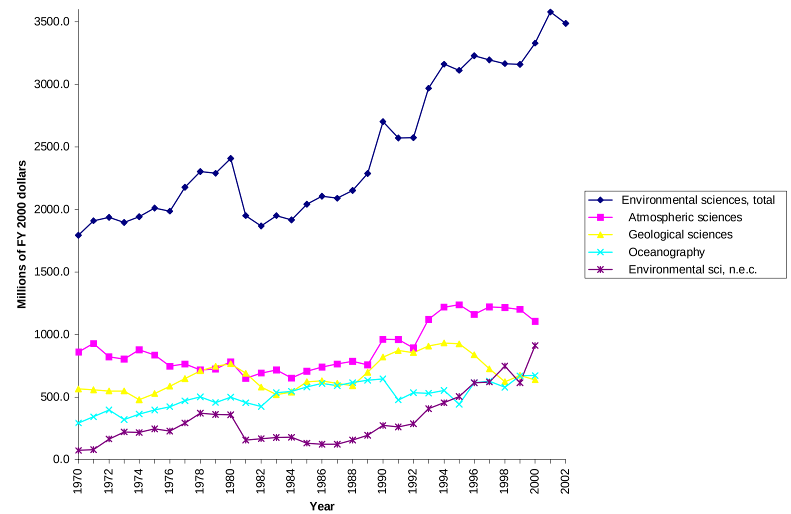


Figure 3-2. Federal Obligations for each Broad Field of S&E and its Component Detailed Fields: FY 1970–2002 (continued)
(constant FY 2000 dollars)

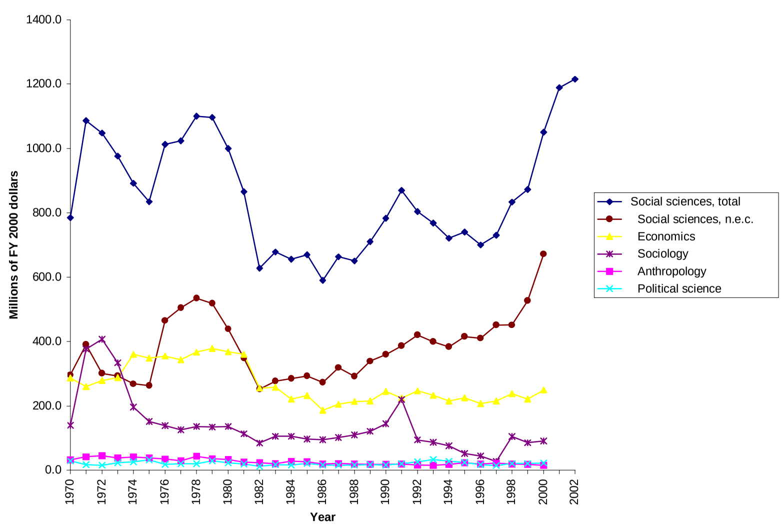
Psychology



Environmental Sciences



Social Sciences



NOTE: FY 2001 and 2002 data are preliminary.

SOURCE: RAND, based on NSF, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds: Detailed Historical Tables: Fiscal Years 1951–2001.

The next five years, 1986 to 1990, were a period of growth for most fields (Figure 3-1). After hitting a low in 1986, funding for the social sciences increased 33 percent by 1990. Likewise, funding for the environmental sciences was up 28 percent. Funding for engineering fluctuated, hitting a high in 1989, and then in 1990 hitting its lowest level since 1977.

Recent Trends in Funding of Science and Engineering Fields

Growth in federal funding of research continued through 1993, when funding for most fields peaked (Figure 3-1; also see Appendix I, Tables 11 and 12). From 1994 to 1997, with a political consensus to reduce the budget deficit and reductions in the defense budget after the end of the Cold War, federal funding of research leveled out in inflation adjusted terms, with federal funding of research in 1997 being just slightly higher than it was in 1993. A 1999 study of trends in federal research funding commissioned by the National Academies' Board on Science, Technology, and Economic Policy (STEP) showed that a number of agencies spent less on research in 1997 than they had in 1993, including the DOD, down 28 percent; the Department of the Interior (DOI), down 13 percent; the Department of Agriculture (USDA), down 6 percent; and the DOE, down 6 percent (McGeary and Merril, 1999). In contrast, the research budget of the NIH had increased by 11 percent. These cuts disproportionately affected most fields in the physical sciences (physics, chemistry, and geology), engineering (chemical, civil, electrical, and mechanical), and mathematics because they received most of their support from agencies with reduced research funding (McGeary and Merril, 1999). Federal funding of four fields decreased by 20 percent or more between 1993 and 1997: mechanical engineering (41 percent), electrical engineering (35 percent), physics (28 percent), and geological sciences (20 percent) (Figure 3-2; also see Appendix I, Tables 13 and 14).[8] In contrast, funding increased for computer sciences (41 percent), medical sciences (16 percent), and metallurgy and materials engineering (14 percent).[9] These findings led the Board to express its concern about the long-term implications of reduced federal investment in fields important to such industries as electronics, software, networking, and materials processing and to advances in the life sciences (McGeary and Merril, 1999).

Federal funding for S&E research increased in 1998 after five years of stagnation, up 5 percent over the level in 1993. In 1999, it was up 12 percent over 1993, and in 2000 it was up 26 percent (Figure 3-1). Preliminary numbers for federal research obligations for FY 2001 and FY 2002 indicate continued growth: federal funding of research in FY 2001 is projected to be 11 percent above FY 2000 levels, and FY 2002 is projected to be 13 percent above FY 2000 levels (see Appendix I, Table 13).

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[8]Please note that, in FY 1996, NSF changed its classification of engineering research activities so that its support of mechanical engineering appeared to be much less—NSF's funding of mechanical engineering went from $54.5 million in 1995 to $6.1 million in 1996 (STEP, 2001). This reclassification accounts for a significant part of an apparent decline in total funding of mechanical engineering between 1995 and 1996 and subsequent years. If funding levels are adjusted for the reclassification, the overall decrease in federal funding of mechanical engineering between 1993 and 1997 is 41 percent instead of 50 percent.

[9]Please note that in FY 1996, NSF changed its classification of environmental sciences research activities so that its support of oceanography appeared to be much greater—NSF's funding of oceanography went from $84.5 million in 1995 to $209.4 million in 1996 (STEP, 2001). This reclassification accounts for a significant part of an apparent increase in total funding of oceanography between 1995 and 1996 and subsequent years. If funding levels are adjusted for the reclassification, the overall increase in federal funding of oceanography between 1993 and 1997 is eliminated; instead there would be a 6 percent decrease in overall funding.

Most of these recent increases in federal research funding can be accounted for by increased support by the NIH. In FY 1999, Congress began its campaign to double the NIH budget by FY 2003. These increases in the NIH budget have dominated the growth of overall federal research funding and have greatly increased the amount of federal funding for the life sciences, which experienced a 47 percent increase from 1993 to 2000. Preliminary numbers indicate even greater increases in FY 2001 and FY 2002 (see Appendix I, Tables 11 and 12).

In 2001, the STEP Board published "Trends in Federal Support of Research and Graduate Education," a follow-up to its 1999 study of trends in federal research funding. In this more-recent report, the STEP Board found that funding for the life sciences had increased to 46 percent of federal funding for research in 1999, compared to 40 percent in 1993, while funding for the physical sciences and engineering decreased from 37 percent of the research portfolio in 1993 to 31 percent in 1999 (STEP, 2001).[10] Specifically, the STEP Board found that federal funding in 1999 was still below 1993 levels for several fields of research: mechanical engineering (down 54 percent),[11] electrical engineering (down 29 percent), chemical engineering (down 26 percent), geological sciences (down 26 percent), physics (down 25 percent), and chemistry (down 13 percent) (Figure 3-2). In contrast, federal funding increased for most of the other fields of research, with several realizing increases of over 20 percent between 1993 and 1999: computer sciences (up 65 percent), medical sciences (up 39 percent), oceanography (up 26 percent), biology (up 21 percent), and aeronautical engineering (up 21 percent).[12] The STEP Board concluded that a substantial shift had occurred in the composition of the federal research portfolio, resulting in substantial reductions in federal funding of the physical sciences and certain fields of engineering, and substantial increases in the life sciences (STEP, 2001).

Most of the trends of the late 1990s have continued in FY 2000 (the last year for which actual data are available for federal research obligations) (see Appendix I, Table 14). Some fields continued to experience increases in federal funding between 1993 and 2000, such as biology (up 97 percent), computer sciences (up 77 percent), and mathematics (up 31 percent). Some fields continued to have less funding in 2000 than in 1993, including physics (down 20 percent), the geological sciences (down 30 percent), chemical engineering (down 30 percent), electrical engineering (down 26 percent), and mechanical engineering (down 46 percent). In contrast, some fields that had more funding in 1999 than in 1993 had less funding in 2000—astronautical engineering experienced an 8 percent drop in funding between 1993 and 2000, and civil engineering experienced a 17 percent drop—while astronomy, which had less funding in 1999 than in 1993, had 13 percent more funding in 2000 than 1993. However, preliminary numbers indicate that federal funding of most of the broad fields of S&E will experience increased federal funding in FY 2001 and FY 2002 (see Appendix I, Table 12).

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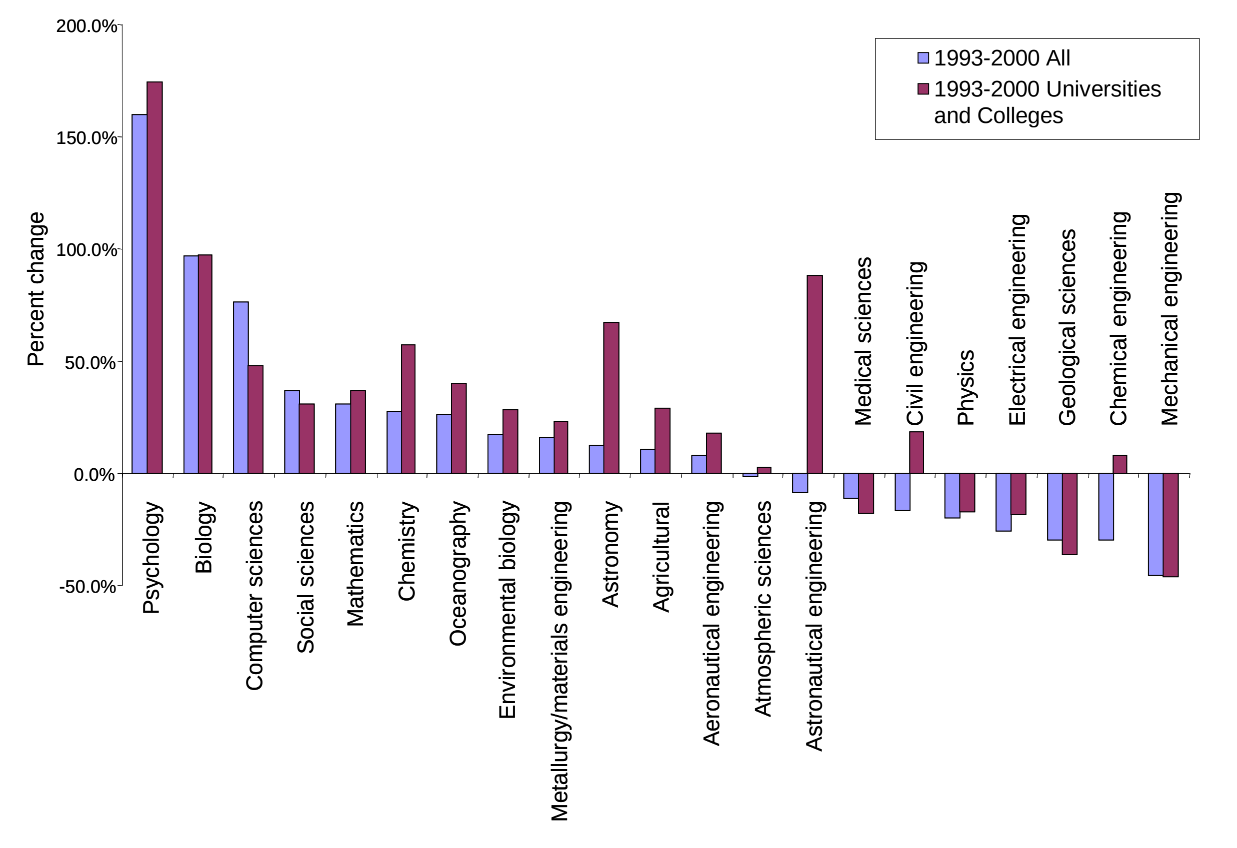
[10]Data in the STEP Board Report "Trends in Federal Support of Research and Graduate Education" were converted to constant 1999 dollars. However, data presented here in PCAST Issue 3, R&D Balance, have been converted to constant 2000 dollars. Therefore, the values presented here may not exactly match those that were presented in the STEP Board report.
[11]See footnote 10 above.
[12]See footnote 10 above.

Some fields appeared to experience uncharacteristically large increases in funding between FY 1999 and FY 2000, particularly psychology, the social sciences, the environmental sciences, and the physical sciences (Figure 3-2). NIH's reclassification of all its development activities into basic and applied research accounts for a significant part of these apparent increases (see Users Notes on *Reclassification of Federal Development Obligations*). NIH funding of psychology went from $489.0 million in FY 1999 to $1.5 billion in FY 2000; funding of the social sciences went from $121.8 million to $232.6 million; funding of the environmental sciences went from $40.2 million to $361.9 million; and funding of the physical sciences went from $208.1 million to $610.8 million (in constant FY 2000 dollars) (see Appendix I, Table 2). If funding levels are adjusted for the reclassification, the overall increase in federal funding of these fields between FY 1999 and FY 2000 is not as large (e.g., psychology would increase by 1 percent instead of 160 percent), and in some cases is eliminated altogether (e.g., the environmental sciences would decrease by 5 percent instead of increasing by 12 percent.

Figure 3-3. Change in Federal Research Obligations for All Performers and University and College Performers, by Detailed Field of S&E: FY 1993–2000
(constant FY 2000 dollars)



SOURCE: RAND, based on NSF, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002

The trends in federal funding of research performed at universities and colleges between FY 1993 and FY 2000 were comparable to overall funding of research, but the increases in funding were more favorable for universities and colleges, suggesting that agencies were tending to fund more research at universities and colleges than research by other performers (Figure 3-3). Even the physical sciences and engineering fared relatively well at universities and colleges as compared to overall funding of these fields. Preliminary numbers indicate that these increases in federal funding of research at universities and colleges will continue in FY 2001 and FY 2002 (see Appendix I, Table 15).

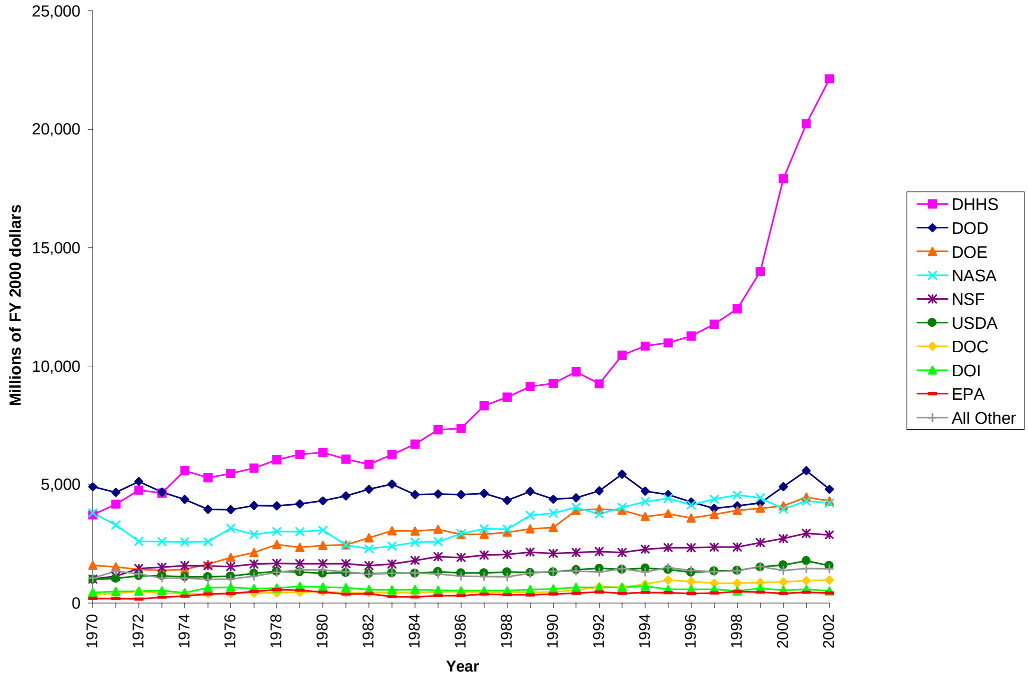
One area of significant growth in federal funding during the last decade was in areas of new and multidisciplinary fields (fields classified by NSF as “not elsewhere classified” [n.e.c.]). Since 1970, when NSF introduced its field of research taxonomy, it has only been modified by the addition of computer science in 1976 and environmental biology and agricultural sciences in 1978 (STEP, 2001). However, over the last 20 years, there has been a growth of inter- and multidisciplinary research; some fields have shifted focus and approach; related fields have integrated; and new fields have emerged (STEP, 2001). Most of these changes are accounted for in the n.e.c. category. For example, “engineering, n.e.c.” includes agricultural, bioengineering, biomedical, industrial and management, nuclear, ocean, and systems engineering. While federal funding of most engineering fields was either decreasing or stagnant over the last 10 years, funding of engineering n.e.c. went from $865.0 million in FY 1990 to almost $2 billion in FY 2000 (in constant FY 2000 dollars) (Figure 3-2; also see Appendix I, Table 13). Likewise, funding for the broad field of Other Sciences n.e.c. increased from $824.5 million in FY 1990 to $1.2 billion in FY 2000, and preliminary numbers indicate that it will increase even more in FY 2001 and FY 2002. Increases in federal funding of these not-elsewhere-classified fields of research may represent potentially overlooked growth in S&E funding.

Funding of Science and Engineering Fields by Federal Agencies

There are 28 federal departments and agencies that fund S&E research. Of these, five agencies account for over 85 percent of the total research funding, and nine account for over 95 percent of funding (Figure 3-4; also see Appendix I, Table 16). Since 1970, funding of research by DHHS has steadily increased, surpassing funding by all other agencies in the early 1970s. In FY 2000, DHHS alone funded 47 percent of the total federal S&E research portfolio as compared to 21 percent in FY 1970. The vast majority of DHHS support for S&E research comes from NIH—in FY 2000 NIH accounted for 94 percent of the total DHHS-funded research.

The second largest funder of research is DOD, followed closely by DOE, NASA, and NSF (Figure 3-4). DOE and NSF have increased their funding of research more than 2.5-fold since FY 1970. In contrast, funding of research by DOD and NASA is only slightly higher than it was in FY 1970, and as a share of the total federal research portfolio, DOD-funded research has dropped from 27 percent in FY 1970 to 13 percent in FY 2000, and NASA-funded research has dropped from 21 percent to 10 percent. In FY 2000, DOD, NASA, the EPA, and the DOI all funded less research than in FY 1993.

Figure 3-4. Total Federal Obligations for Research, by Agency: FY 1970–2002
(constant FY 2000 dollars)



NOTE: FY 2001 and 2002 data are preliminary.

SOURCE: RAND, based on NSF, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds: Detailed Historical Tables: Fiscal Years 1951–2001.

Figure 3-5 shows the top funding agencies for each broad field of S&E. Funding for the life sciences, the most highly funded field of S&E, is primarily from DHHS. The vast majority of DHHS-funded life sciences research is funded by NIH, which mainly supports research in biology and the medical sciences. DHHS-funded research in the life sciences has increased more than 4.5-fold since FY 1970. The second largest funder of the life sciences is the USDA, which spends one-tenth of the amount spent by DHHS and mainly supports the agricultural sciences.

DOD is the biggest funder of research in engineering, and is the primary supporter of research in civil, electrical, mechanical, and metallurgy and materials engineering (Figure 3-5). However, since FY 1993, DOD funding levels have dropped for all types of engineering, except aeronautical engineering. NASA also funds a large amount of engineering research, focusing mainly on aeronautical and astronautical engineering. Funding for engineering research by NASA was less in FY 2000 than in FY 1993. Although funding for engineering by DOE and NSF increased between FY 1993 and FY 2000, the majority of the increase was due to increased funding of metallurgy and materials engineering. DOE, the primary funder of chemical engineering, was funding less chemical engineering research in FY 1993 than in FY 2000.

DOE is the largest funder of research in the physical sciences, and is the primary supporter of research in physics and chemistry (Figure 3-5). However, since FY 1993, funding of the physical sciences by DOE has decreased by 20 percent. NASA is the primary supporter of research in astronomy and also funds some research in physics. NASA's funding of the physical sciences increased from the early 1980s through the early 1990s and then leveled off through FY 1999, increasing slightly in FY 2000. Funding of the physical sciences, especially chemistry and physics, by DOD has steadily declined since FY 1983, dropping almost three-fold by FY 2000.

Federal funding of math and computer sciences has increased significantly since FY 1970, mainly due to large increases in funding by DOD, DOE, and NSF (Figure 3-5). Historically, DOD has funded the majority of math and computer sciences, primarily focusing on computer sciences research. However, in the 1990s, both DOE and NSF greatly increased the amount of math and computer sciences they funded, and by FY 2000, DOE was funding more research in math and computer sciences than DOD. In addition, DHHS and the Department of Commerce (DOC) began increasing their funding of math and computer sciences in the early 1990s.

NASA is the largest funder of research in the environmental sciences, and is the main supporter of research in atmospheric sciences (Figure 3-5). After a considerable drop in funding during the 1980s, funding of the environmental sciences by NASA increased more than 2.5-fold by FY 2000. NSF is the primary supporter of research in oceanography, providing more funding than the National Oceanic and Atmospheric Administration (NOAA) that is part of DOC. Although funding of the environmental sciences by NSF declined after the 1980s and was fairly stagnant through the 1990s, funding of oceanography increased by more than two-fold between FY 1993 and FY 2000 (mainly due to a reclassification of the environmental sciences by NSF). The Geological Survey at DOI is the primary funder of research in the geological sciences. Although funding of the environmental sciences by DOI increased between FY 1970 and FY 2000, funding for the geological sciences decreased between FY 1993 and FY 2000.

DHHS is also the main funder for psychology and the social sciences (Figure 3-5). Funding of psychology by DHHS has increased steadily since the mid-1980s, while funding by DOD and NSF has decreased considerably since the mid-1990s. In contrast, funding of the social sciences by DHHS has been a roller-coaster ride, peaking in the mid 1970s and then dropping off precipitously in the early 1980s, peaking again in the early 1990s only to plummet again in the late 1990s.[13] Funding by NSF of social sciences research has increased since FY 1990, while funding by the USDA, which is the primary supporter of economics research, has been stagnant.

In summary, since the mid-1980s, the trend in overall federal funding for science and engineering research has been generally upward. Beginning in the late 1990s, this trend has been dramatically upward. During this same period and even earlier, the allocation of funds among the various fields of science and engineering has shifted markedly, however, with the life sciences accounting for an ever-increasing proportion of the federal R&D portfolio. Multidisciplinary and new fields of science and engineering also experienced substantial growth during these years. Meanwhile, federal support for many fields of engineering and the physical sciences decreased significantly, posing potential problems in the coming years for a number of U.S. industries.

[13]The apparent increases in DHHS funding of psychology and the social sciences in FY 2000 is primarily due to NIH's reclassification of all of its development activities into basic and applied research (see section above on *Recent Trends in Funding of Science and Engineering Fields* and Users Notes on *Reclassification of Federal Development Obligations*).

Figure 3-5. Federal Obligations for each Broad Field of S&E, by Agency: FY 1970–2002
(constant FY 2000 dollars)

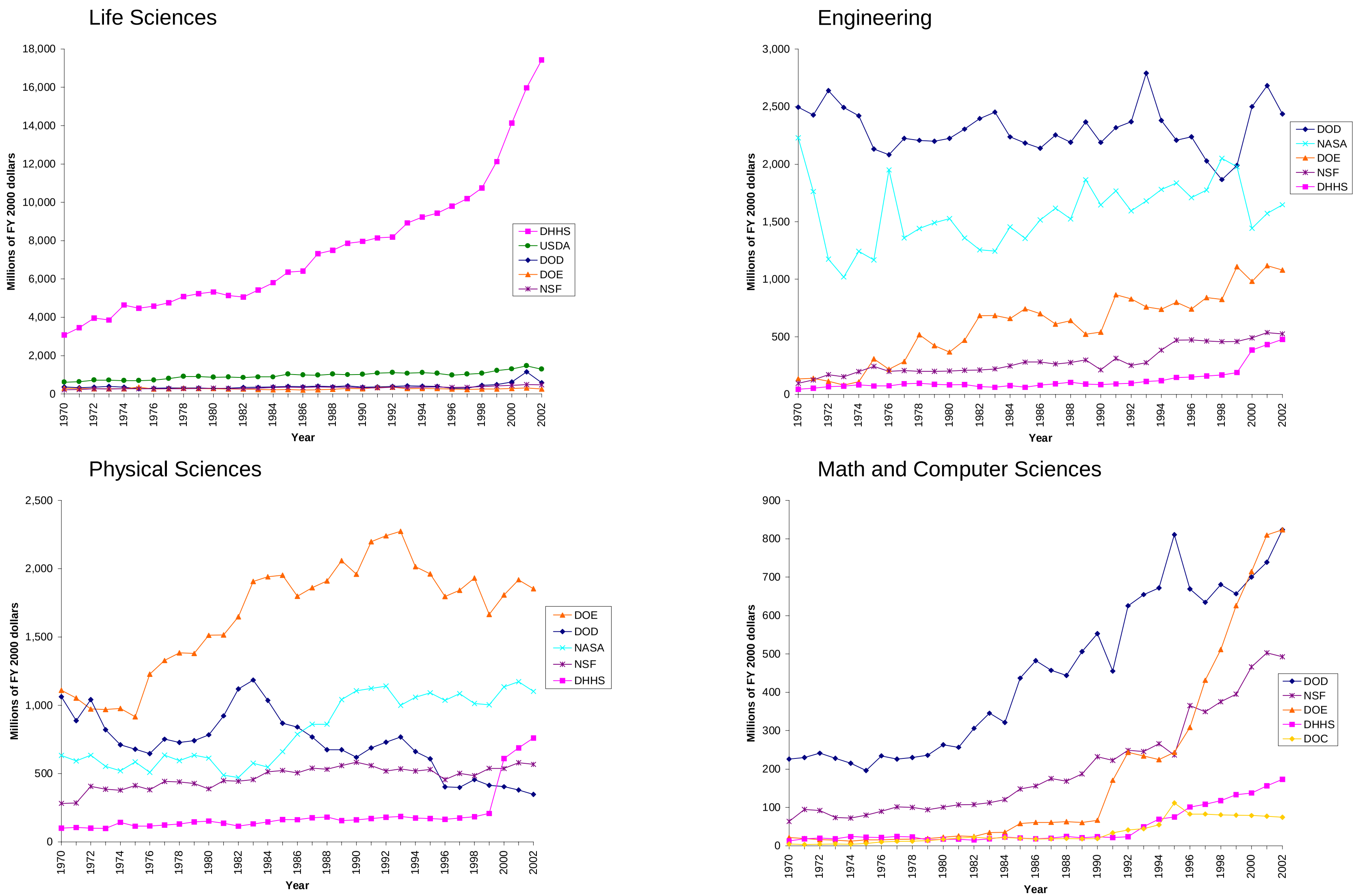
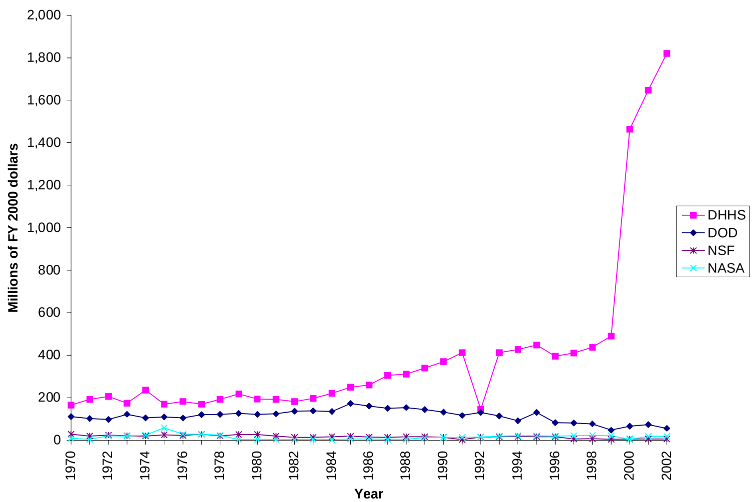
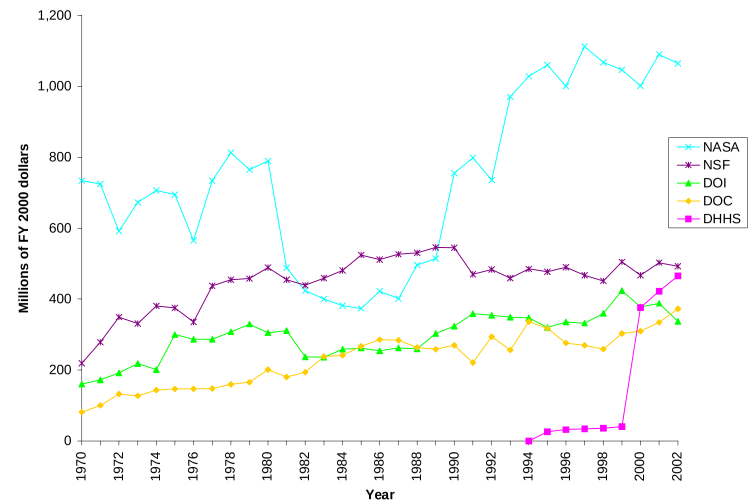


Figure 3-5. Federal Obligations for each Broad Field of S&E, by Agency: FY 1970–2002 (continued)
(constant FY 2000 dollars)

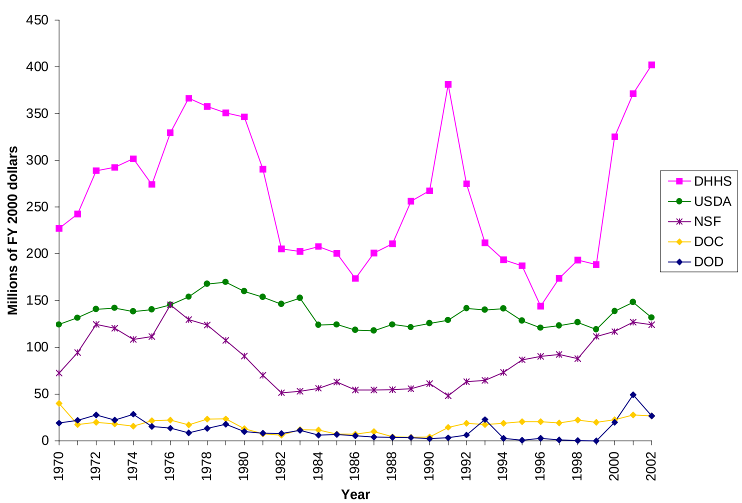
Psychology



Environmental Sciences



Social Sciences



NOTE: FY 2001 and 2002 data are preliminary.

SOURCE: RAND, based on NSF, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds: Detailed Historical Tables: Fiscal Years 1951–2001.

CHAPTER 4

The adequacy of human resources in science and engineering has been a topic of much discussion in the United States. PCAST was interested in the affects of shifts in funding among the fields of S&E on graduate education and the U.S. workforce, as well as on the research outputs of scientists and engineers. PCAST raised the following issues:

> Identify changes in U.S. science and engineering graduate education and the U.S. scientific and technological workforce. Identify changes in patents awarded to U.S. universities and colleges and articles published in major scientific and technical journals. Explore the possible ramifications of these trends for U.S. productivity and economic growth.

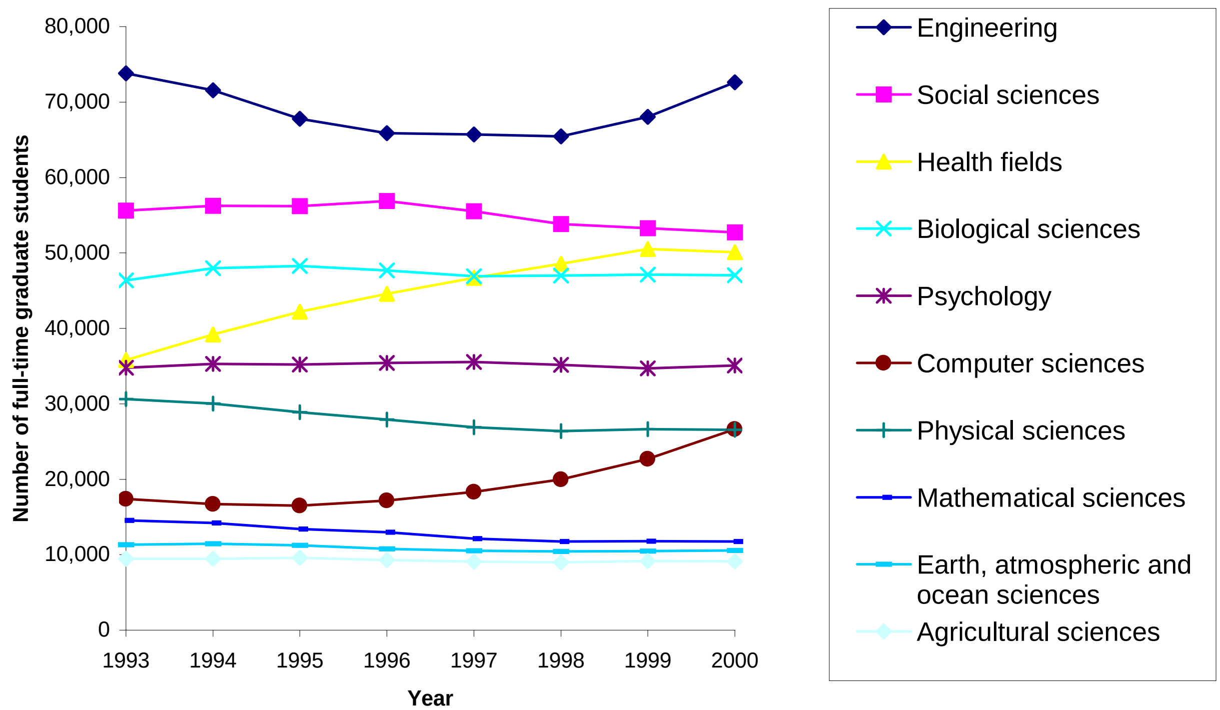
To obtain more information on which to base its deliberations, PCAST asked for data on science and engineering graduate enrollment and doctorates awarded, and the U.S. science and technological workforce, as well as data on changes in articles published in major journals and patents awarded to universities and colleges, as measures of research outputs of U.S. scientists and engineers.

Education

In addition to performing almost half of the nation's basic research, universities and colleges in the United States train new generations of researchers (NSB, 2002). In 2000, the federal government supported almost 60 percent of R&D performed at U.S. universities and colleges (NSB, 2002). In the 1990s, of all the degrees awarded by universities and colleges, about 35 percent of bachelor's degrees, 30 percent of master's degrees, and more than 60 percent of the doctorates were awarded in S&E fields (NSB, 2002). Trends in federal funding of research at universities and colleges can affect graduate student enrollment by providing support for graduate research assistantships and by shaping the job market in S&E fields (STEP, 2001).

The number of full-time graduate students enrolled in science and engineering fields declined between 1993 and 2000, hitting lows in 1998 and then rebounding to just below 1993 levels by 2000. The number of graduate students in most fields either declined or was stagnant (Figure 4-1; also see Appendix I, Tables 17 and 18). There were fewer graduate students in the physical sciences in 2000 than in 1993—21 percent fewer in physics and 9 percent fewer in chemistry. The mathematical sciences had 19 percent fewer graduate students, and the earth, atmospheric and ocean sciences (atmospheric sciences, geosciences and oceanography) had 7 percent fewer graduate students. The agricultural sciences, social sciences, and most of the engineering fields also had fewer graduate students in 2000 than in 1993. The number of graduate students in the biological sciences and psychology remained fairly stagnant between 1993 and 2000. The only S&E fields that had significantly more graduate students in 2000 than in 1993 were the computer sciences (up 53 percent), biomedical engineering (up 27 percent), and electrical engineering (up 12 percent). The number of graduate students in health fields also increased dramatically between 1993 and 2000, with 40 percent more graduate students in health fields in 2000 than in 1993.

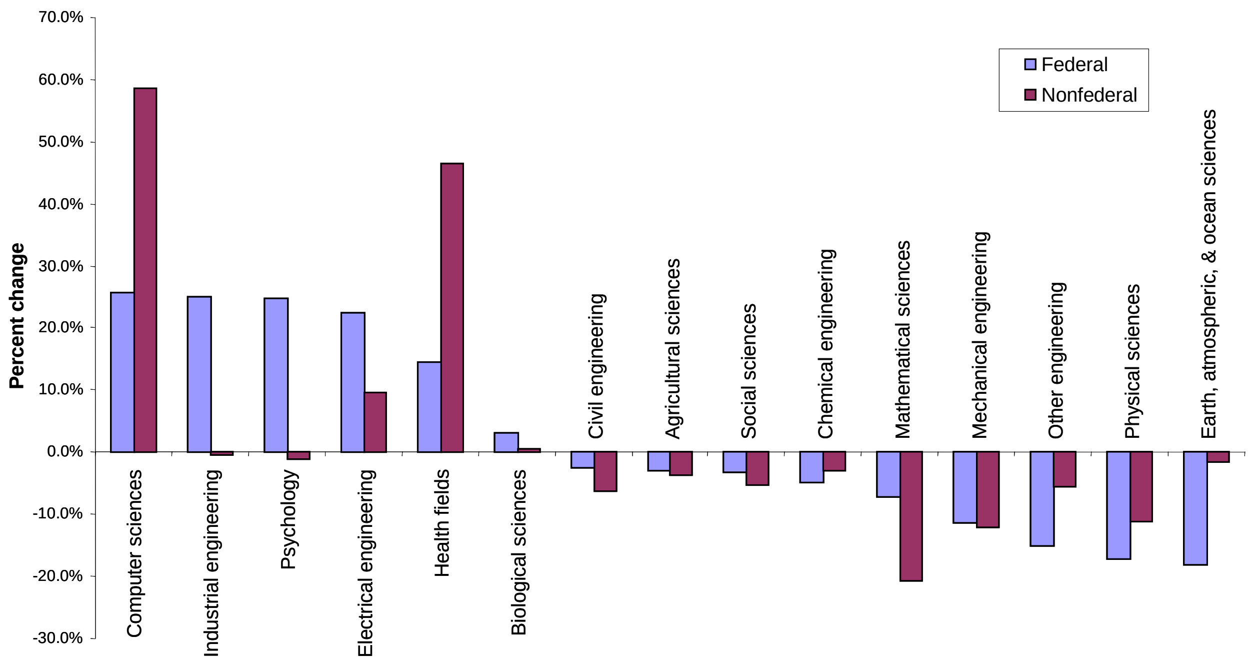
Figure 4-1. Full-Time Graduate Students in Science, Engineering, and Health Fields, by Field: 1993–2000



SOURCE: RAND, based on NSF, Graduate Students and Postdoctorates in Science and Engineering, Fall 2000

Overall, the number of S&E graduate students receiving federal support dropped 2 percent between 1993 and 2000, while the number of graduate students in health fields receiving federal support increased by 15 percent (Figure 4-2; also see Appendix I, Table 18). The number of federally funded graduate students increased by more than 20 percent in computer sciences (26 percent), industrial engineering (25 percent), psychology (25 percent), and electrical engineering (22 percent). In contrast, the number of federally funded graduate students decreased for most other fields, with the physical sciences experiencing a 17 percent decrease and the earth, atmospheric, and ocean sciences experiencing an 18 percent decrease.

Figure 4-2. Change in Full-Time Graduate Student Enrollment in Science, Engineering, and Health Fields, by Field and Primary Source of Support: 1993–2000

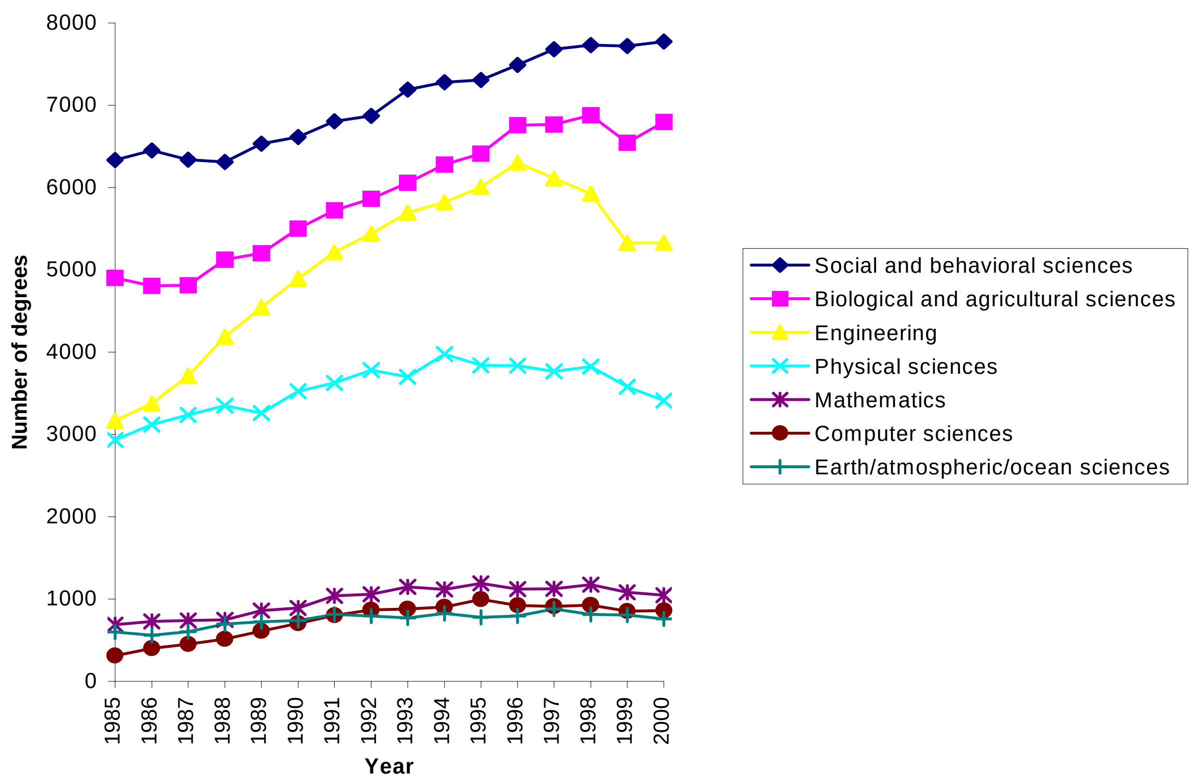


SOURCE: RAND, based on NSF, Graduate Students and Postdoctorates in Science and Engineering, Fall 2000

The trends for doctoral degrees in S&E were slightly different from those for all full-time graduate students. The general trend for most fields was increasing numbers of S&E doctoral degrees awarded through the mid- to late 1990s and then declining numbers at the turn of the century (Figure 4-3; also see Appendix I, Tables 19 and 20). There were more graduate students earning doctorates in the social sciences, biological sciences, and psychology in 2000 than in 1993. However, fewer doctorates were being awarded in the geosciences, physics, chemistry, mathematics, computer sciences, and most of the fields of engineering.

How do these trends in graduate student enrollment and number of doctorates awarded compare to the trends in federal funding for science, engineering, and health fields? In 2001, the National Academies' Board on Science, Technology, and Economic Policy (STEP) found that graduate enrollments and Ph.D. production were generally down in fields that had less federal funding in 1999 than in 1993 (STEP, 2001). This trend continued in 2000. For example, graduate student enrollment and the number of doctorates awarded decreased in physics, geological sciences, and mechanical engineering between 1993 and 2000, and federal funding decreased 20 percent or more for these fields. However, it is important to note that fields that experienced the most growth in federal funding over the last two decades did not necessarily experience the most growth in the number of graduate students or doctorates. For example, while biology and the medical sciences both had approximately the same level of funding that grew at the same rate (see Figure 3-2), graduate student enrollment in the health sciences grew much more rapidly than in the biological sciences (see Figure 4-1). And while the computer sciences experienced a 77 percent increase in funding between 1993 and 2000, the number of doctorates awarded in 2000 was slightly lower than in 1993. Furthermore, some fields that experienced decreased funding, such as electrical engineering, nevertheless experienced increases in graduate student enrollment and the number of doctorates awarded.

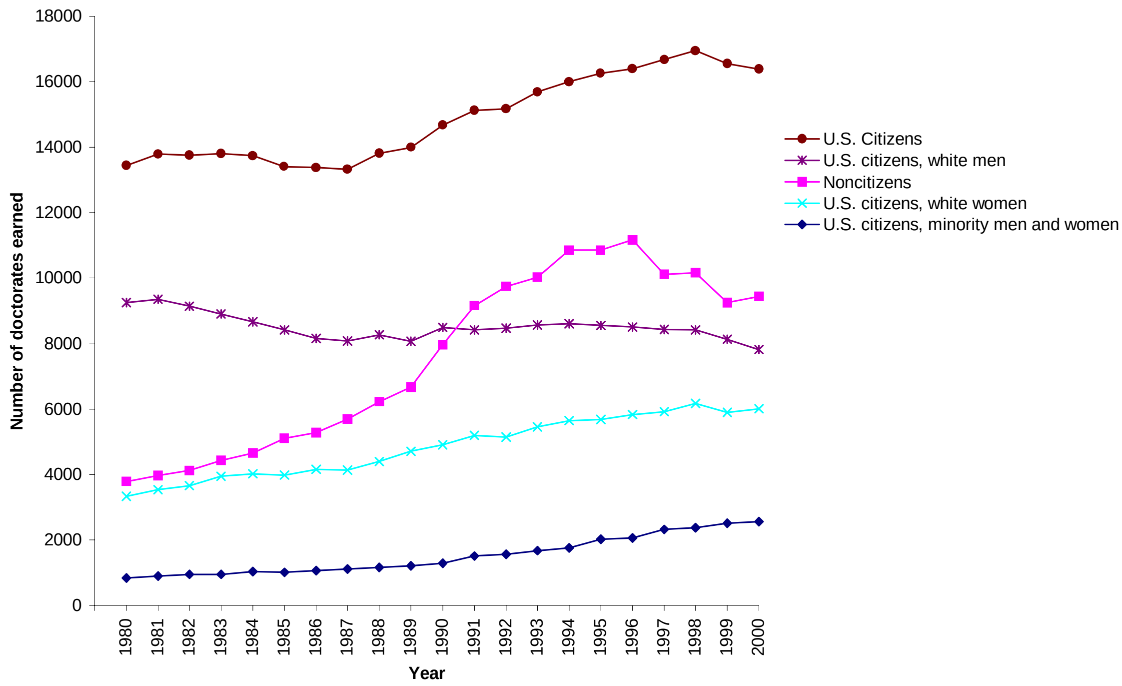
Figure 4-3. Doctoral Science and Engineering Degrees by Field: 1985–2000



SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002; and NSF, Science and Engineering Doctorate Awards: 2000

U.S. science and engineering graduate education attracts large numbers of students from abroad. In the United States in 1999, 10 percent of those holding baccalaureate degrees in S&E, 20 percent holding master's degrees, and greater than 25 percent holding doctorate degrees (much higher in some engineering and computer science fields) were born abroad (NSB, 2002). More than half of the foreign students who have earned S&E doctorates in the United States stay in the United States, a trend that has changed little over time (NSB, 2002). Anecdotes suggest, though, that many scientists and engineers, particularly those originally from Taiwan and South Korea, are beginning to return to their native countries (NSB, 2002).

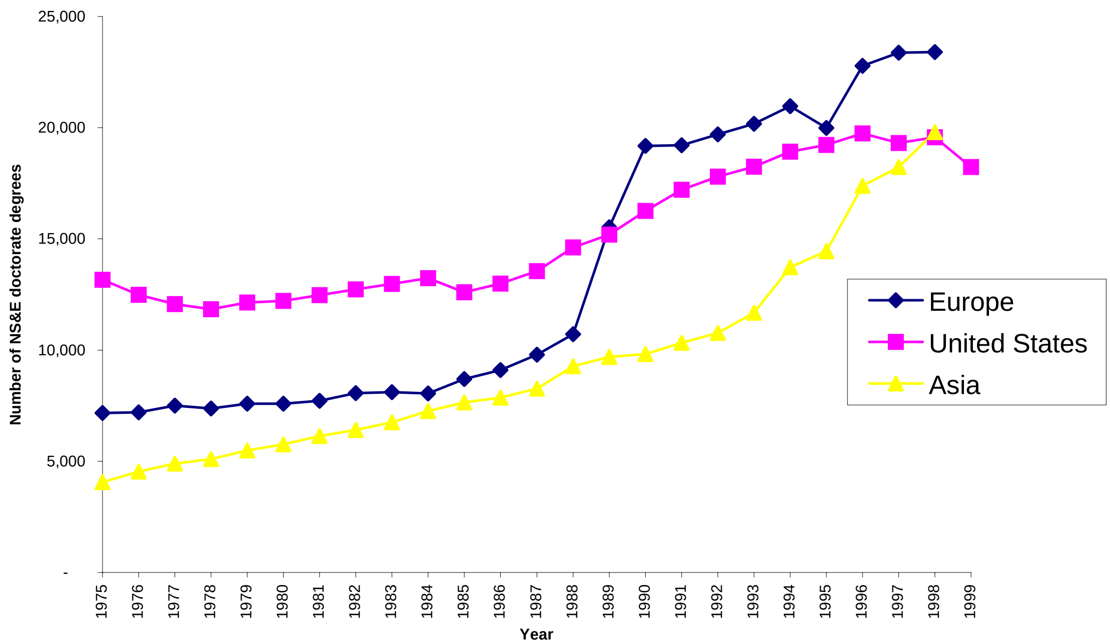
Figure 4-4. S&E and Health Doctorates Awarded to U.S. Citizens and Noncitizens: 1980–2000



SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

Although the number of doctorates awarded in science, engineering, and health fields rose rapidly after the mid-1980s, little growth was seen in the number of doctorates awarded to U.S. citizens (Figure 4-4; also see Appendix I, Table 21). The increase from 1986 to 1999 was mostly due to a growing number of degrees awarded to foreign-born individuals (NSB, 2002). All the growth in S&E and health doctorates earned by U.S. citizens was due to increased numbers of degrees earned by white women and minority students of both sexes (Figure 4-4). In contrast, the number of U.S. white men obtaining these degrees declined 16 percent over the last 20 years. In 2000, white women earned 37 percent of the S&E and health doctorates among U.S. citizens, up from 25 percent in 1980, and minorities earned 15 percent, up from 6 percent. Similar trends are seen for graduate student enrollment in U.S. universities and colleges. The increase in full-time graduate students in science, engineering, and health fields between 1993 and 2000 was due to increases in foreign-born students with temporary visas (up 17 percent), women (up 20 percent), and minorities (up 29 percent); enrollment by white men was down 7 percent (NSB, 2002). Thus, the United States has relied heavily on noncitizens, U.S. white women, and a small but growing number of minority students to sustain its pool of S&E graduate students and the production of doctorates.

Figure 4-5. Doctoral NS&E Degrees in the United States, Europe, and Asia: 1975–1999



NOTE: Europe includes France, Germany, and the United Kingdom.
Asia includes China, India, Japan, South Korea, and Taiwan.
French doctoral degrees are not available in the same data series before 1989.
German doctoral degrees include those of former East Germany from 1990 on.
Natural sciences include: physics, chemistry, astronomy, mathematics,
and earth, atmospheric, ocean, biological, agricultural, and computer sciences.

SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

Not only are the numbers of noncitizens earning S&E doctorates in the United States rising, but the number of S&E doctorates awarded has also been steadily rising in several European and Asian countries over the last 20 years (see Appendix I, Table 22). Looking specifically at the natural sciences and engineering (NS&E) and excluding the social and behavioral sciences, these trends are even more pronounced.[14] In several European and Asian countries, doctorate degrees awarded in NS&E have grown steadily since 1975 (Figure 4-5). In 1989, the combined total number of NS&E doctorates awarded in the United Kingdom, France, and Germany surpassed those in the United States.[15] In 1998 (the last year for which data was available) the combined total number of NS&E doctorates awarded in China, India, Japan, South Korea, and Taiwan also surpassed those awarded in the United States. In addition, between 1975 and 1999, several countries significantly increased (some almost four-fold) the ratio of college-age youth whose first university degree was in NS&E to the college-age population (NSB, 2002). In contrast, this rate has fluctuated between 4 and 5 percent in the United States for the past four decades and finally reached 6 percent in 1998 (NSB, 2002).

[14]Natural sciences include: physics, chemistry, astronomy, mathematics, and earth, atmospheric, ocean, biological, agricultural, and computer sciences.
[15]The large increases in doctoral NS&E degrees in Europe in 1989 and 1990 are due to the inclusion of previously unavailable data on French doctoral degrees, and the inclusion of doctoral degrees from East Germany, respectively.

Workforce

Over the past two decades, the S&E workforce in the United States has grown faster than the overall civilian labor force, and this growth is expected to continue (NSB, 2002). In 1999, 10.5 million individuals out of a civilian labor force of about 140 million held S&E degrees (Table 4-1) (NSB, 2002). Of the 8 million scientists and engineers in the workforce whose highest degree was in an S&E field, approximately 3 million were employed in S&E-related jobs. Of these 3 million, 1.3 million were engineers; 0.5 million were computer scientists and mathematicians; another 0.5 million were social scientists; 0.4 million were life scientists; and 0.3 million were physical scientists. By subfield, electrical engineers made up about one-fourth of all those employed as engineers; biologists accounted for about three-fifths of those employed in the life sciences; chemists made up about two-fifths of all employed physical scientists; and psychologists accounted for over half of all employed social scientists (NSB, 2002). In contrast, approximately 5 million individuals, whose highest degrees were in S&E, were not employed in an S&E occupation, although many were still using their S&E training, employed in fields that were somewhat related to science or engineering, such as management or administrative positions, sales and marketing jobs, or non-S&E-related teaching positions (NSB, 2002).

Table 4-1. Employed Scientists and Engineers, by S&E Employment Status and Field of Degree: 1999

	Employment Status		
Employee Characteristic	Total	S&E	Non-S&E
Total employed	10,981,600	3,540,800	7,440,800
No S&E degree	501,800	282,000	219,800
S&E degree	10,479,800	3,258,800	7,221,000
S&E is highest degree	7,980,000	3,003,200	4,976,800
Computer sciences and mathematics	1,045,800	537,200	508,600
Life and related sciences	1,287,700	361,700	926,000
Physical and related sciences	621,700	343,000	278,700
Social and related sciences	3,088,400	458,000	2,630,400
Engineering	1,936,400	1,303,300	633,100
Non-S&E is highest degree	2,499,800	255,600	2,244,200

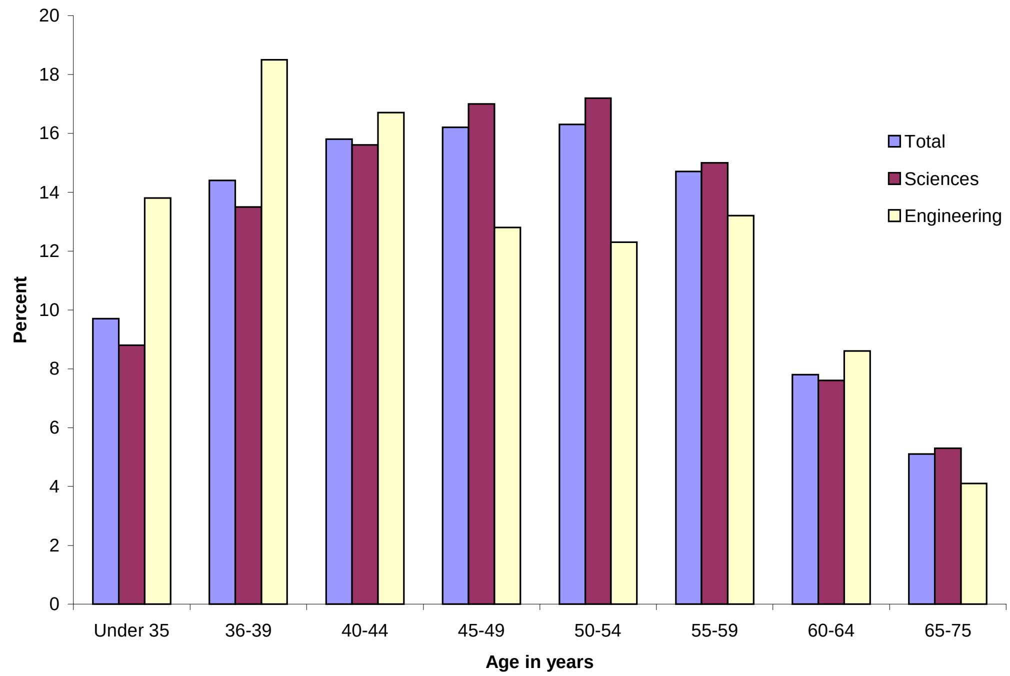
SOURCE: NSB, Science and Engineering Indicators—2002

Industry is the largest job source for scientists and engineers, employing 73 percent of those with S&E bachelor's degrees, 62 percent of those with master's degrees, and 31 percent of those with doctorates (NSB, 2002). In 1999, industry employed more than three-fourths of computer scientists, mathematicians, and engineers but only about one-fourth of life scientists and one-fifth of social scientists (NSB, 2002). Academia is the second largest employer of scientists and engineers but the largest employer of S&E doctorate holders, employing 48 percent of those with doctorates (NSB, 2002). In 1999, academia employed almost half of all life scientists and social scientists (NSB 2002). The federal government employs only 4–5 percent of bachelor's and master's degree recipients, employing more engineering graduates than science graduates (NSB, 2002).

The number of foreign-born scientists and engineers in the United States has grown at all degree levels, in all sectors, and in most fields over the last 25 years (NSB, 2002). In 1999, 25 percent of all U.S. S&E doctorate holders were born abroad, with especially high percentages in engineering (45 percent), computer sciences (43 percent), and mathematics (30 percent), fields that have experienced little or no growth in domestic doctorate production (NSB, 2002). In 1999, one-third of all S&E doctorate holders working in industry were born abroad—more than half of engineers and computer scientists, and more than one-third of mathematicians were foreign born (NSB, 2002). In academia, foreign-born individuals with doctorate degrees account for almost 40 percent of full-time faculty in computer sciences, 35 percent in engineering, and 28 percent in mathematics (NSB, 2002). In 1999, 16 percent of doctorate holders working in the federal government were born abroad; in state and local government, 19 percent were born abroad (NSB, 2002). Trends are similar for bachelor's degree holders—in 1980, 11 percent of all baccalaureate recipients in the United States were born abroad, rising to 13 percent in 1990, and to 19 percent in 2000 (NSB, 2002). This dependence on foreign-born scientists and engineers in the workforce mirrors the increased number of foreign-born graduate students at U.S. universities and colleges over the last two decades. With many foreign-born scientists and engineers returning to their native countries, either by choice or because of U.S. immigration requirements, there is a pressing need to expand the domestic pipeline of scientists and engineers (Council on Competitiveness, 2001).

In 1999, 50 percent of the U.S. workforce with doctorate degrees in science were between the ages of 40 and 54 (Figure 4-6; also see Appendix I, Table 23). Engineering doctorates, which accounted for only 17 percent of the workforce in 1999, tended to be a bit younger than scientists, with 50 percent 44 years of age or younger. By field, those with doctorates degrees in computer/information sciences were the youngest—43 percent were younger than age 40. Those with doctorates degrees in aerospace/aeronautical engineering were the oldest—23 percent were 60 years of age or older. However, there also appeared to be an influx of new aerospace/aeronautical engineering doctorates into the workforce—33 percent were below the age of 40. Overall, the largest group of S&E doctorates in the U.S. workforce was 45 to 54 years of age. However, since 1993 there has been a steady increase in the proportion of S&E doctorates ages 55 and older in the workforce, increasing from 20 percent in 1993 to 28 percent in 1999 (see Appendix I, Table 23). These trends are similar for all degree levels, although bachelor's and master's degree holders tended to be a bit younger than those with doctorates (NSB, 2002).

Figure 4-6. Employed doctoral scientists and engineers, by age: 1999



SOURCE: RAND, based on NSF, Characteristics of Doctoral Scientists and Engineers: 1999; and Selected Trend Tables 1993, 1995, and 1997.

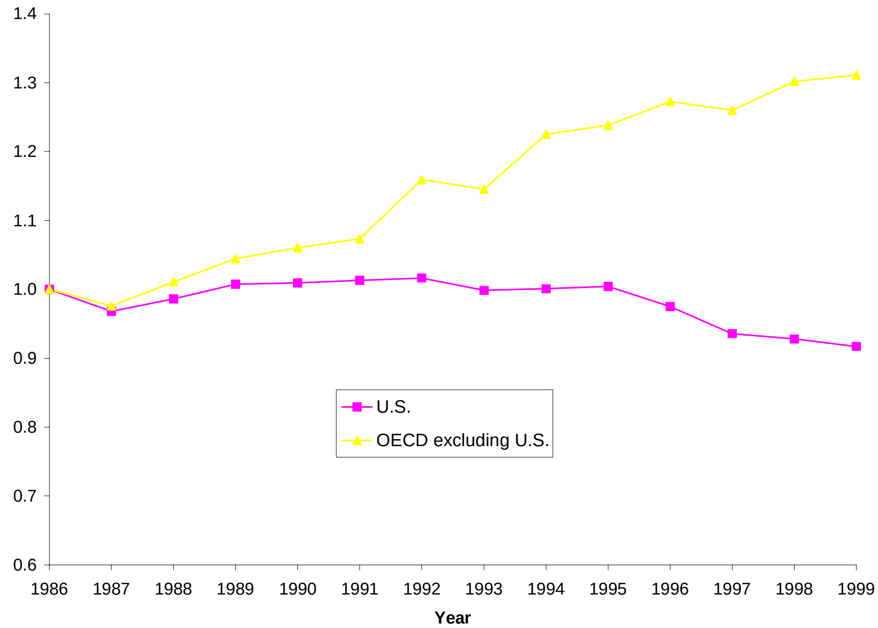
The Council on Competitiveness found that "the aging of the national workforce has produced a massive requirement to replace a generation of skilled wage earners that will reach retirement age by 2005" (Council on Competitiveness, 1998). This impending retirement of millions of skilled workers, which will result in a smaller and relatively less educated and experienced workforce, highlights the need for expanding the pool of U.S. scientists and engineers through investments in education and training (Council on Competitiveness, 2001). In addition, the National Science Board (NSB) found that the retirement rate among workers with S&E degrees would dramatically increase over the next 20 years, especially for those with doctorates in S&E (NSB, 2002). Despite these increases in retirements, the size of the S&E workforce would continue to increase for many years as long as the number of individuals receiving S&E degrees remains higher than the retirement rate of S&E-degreed workers (NSB, 2002). However, the S&E pipeline may not be adequate to address the growing demand for advanced degrees in scientific, engineering and technical disciplines due to static or declining graduate student enrollment in most fields of S&E and decreased federal support for S&E graduate students (Council on Competitiveness, 2001).

Publication of Scientific and Technical Articles

The number of scientific and technical articles published by U.S. authors peaked in 1992 and then decreased steadily throughout the 1990s, and was down 10 percent by 1999 (Figure 4-7). This downward trend in U.S.-authored scientific and technical articles has affected most fields of S&E. The largest decrease in published articles was in engineering and technology, which decreased 26 percent between 1992 and 1999, followed closely by biology, which decreased 22 percent (NSB, 2002). Publishing in the social sciences was down 19 percent, mathematics was down 10 percent, and physics and chemistry were both down by 9 percent (NSB, 2002). In contrast, scientific and technical articles published by other member countries of the Organisation of Economic Co-operation and Development (OECD) have steadily increased since 1987, up more than 30 percent by 1999.

Figure 4-7. Output of Scientific and Technical Papers for the United States and OECD: 1986–1999

1986 Index = 1.0



SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

A country's portfolio of publications can serve as a lagging indicator of its scientific research priorities, and the number of articles published can serve as an indicator of its output of scientific and technical research (NSB, 2002). Table 4-2 compares the portfolios of scientific and technical publications for the United States and other regions in the world. The U.S. portfolio is dominated by publications in the life sciences (55 percent). The only other region to have more publications in the life sciences is Sub-Saharan Africa (67 percent). Twenty-four percent of the U.S. portfolio is dedicated to the physical sciences, 13 percent to the social and behavioral sciences, and only 8 percent to engineering, technology and mathematics. Eastern Europe, Asia, Latin America, the Near-East, and Western Europe all publish a much larger proportion of articles in the physical sciences. In Asia and Eastern Europe the proportion of articles in the physical sciences was greater than that of the life sciences.

Table 4-2. Portfolio of Scientific and Technical Publications, by Region: 1999
(Percent)

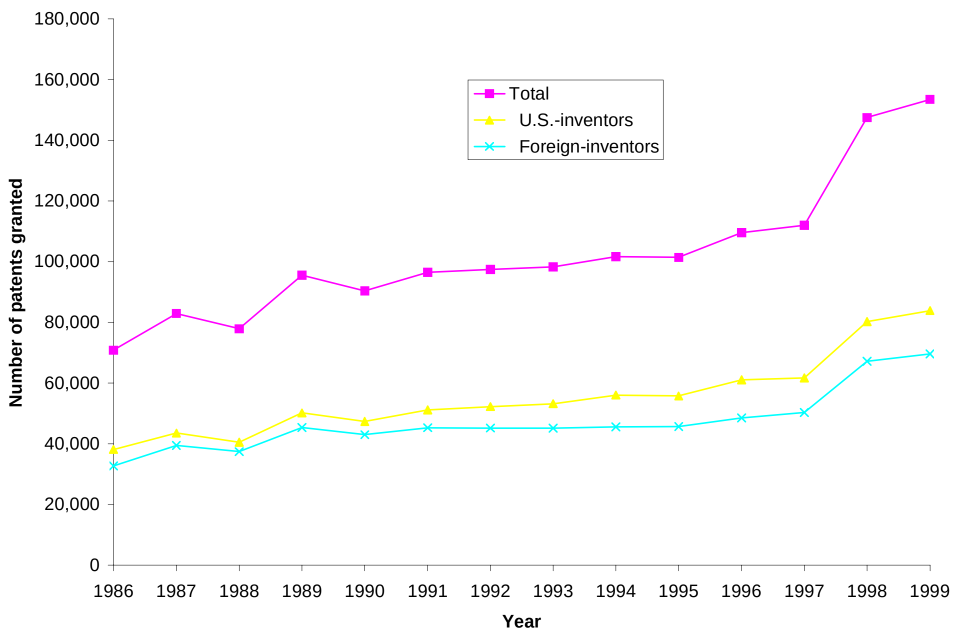
Region	Life sciences	Physical sciences	Engineering, technology & mathematics	Social & behavioral sciences
United States	**55.3**	**24.1**	**7.7**	**12.9**
Sub-Saharan Africa	67.1	19.9	4.3	8.5
Latin America	51.3	38.1	7.4	3.2
Near-East	45.1	36.5	12.7	5.6
Pacific	58.5	23.3	6.9	11.3
Asia	42.1	43.4	12.7	1.7
Eastern Europe	22.9	64.9	9.6	2.6
Western Europe	53.9	32.8	7.9	5.4

SOURCE: NSB, Science & Engineering Indicators—2002

Patents

The number of patents granted in the United States increased more than 2.5-fold between 1990 and 1999, increasing precipitously in the late 1990s to a record high of 153,487 in 1999 (Figure 4-8). Fifty-five percent of the U.S. patents granted in 1999 were issued to U.S. inventors, and 45 percent were issued to foreign inventors, 70 percent of whom were from Germany, Japan, France, and the United Kingdom (NSB, 2002).

Figure 4-8. Number of U.S. Patents Granted: 1986–1999

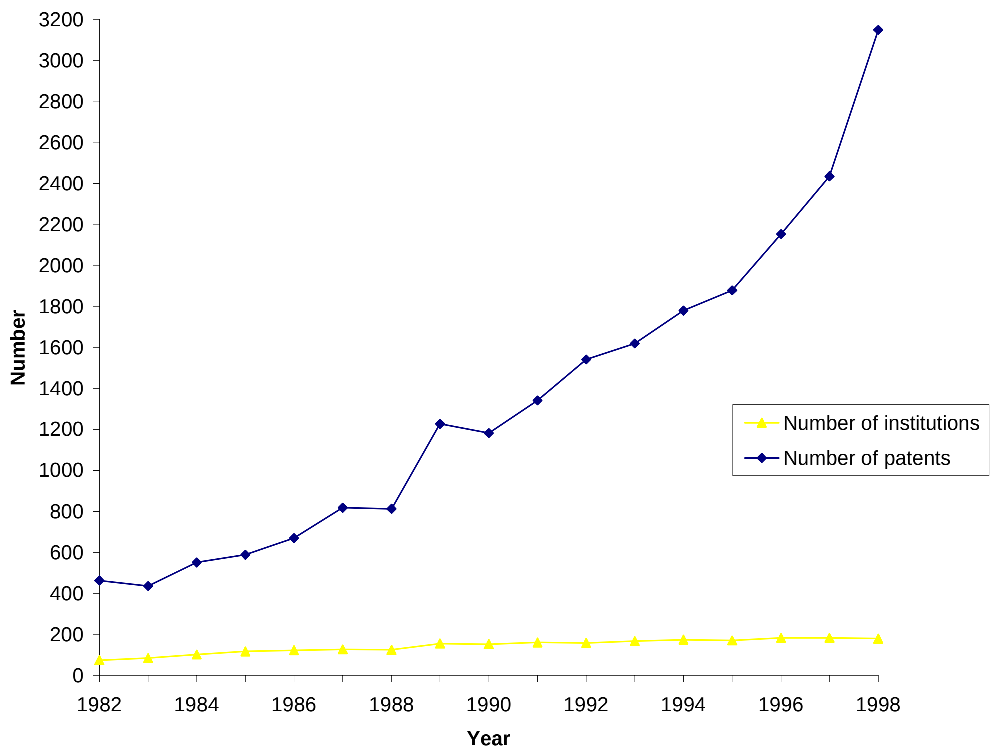


SOURCE: NSB, Science & Engineering Indicators—2002

The number of academic institutions receiving patents increased almost 2.5-fold between 1982 and 1998 (Figure 4-9). However, an even more impressive statistic is the rise in the number of patents granted to these academic institutions, which rose from 464 in 1982 to 3,151 in 1998.

This large increase in the number of patents granted to academic institutions is primarily due to increased numbers of patents in the life sciences and biotechnology (NSB, 2002).

Figure 4-9. Academic Institutions Receiving Patents and U.S. Patents Granted to Academic Institutions



SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

The number of patents issued for automobiles, pharmaceuticals, computing, and electronics has increased dramatically over the last few years (Jonietz, 2002). The increase in patents in the information technologies (computers, telecommunications, and semiconductors) and health technologies (pharmaceuticals, biotechnology, and medical equipment) compared to the patenting of other technologies is significant. More traditional technologies used to account for 85 percent of U.S. patents, and now they account for about 60 percent (Hicks, 2002). Information technology and telecommunications had the greatest increase in the number of patents issued from 2000 to 2001—the number of patents issued increased 21 percent for semiconductor companies, 20 percent for the telecommunications industry, and 12 percent in computing (Jonietz, 2002). Statistics from the U.S. Patent and Trademark Office (PTO) show that these three sectors also had the highest number of new patent applications filed in 2000 (Jonietz, 2002).

Large, well-known companies have historically dominated the patenting process (Jonietz, 2002). For example, IBM has been granted the most patents nine years in a row (Jonietz, 2002). In 2001, IBM received 3,454 patents, which is almost 10 patents a day (Jonietz, 2002). However, newer companies in the biotechnology and semiconductor industries are also aggressively protecting their intellectual property by filing patents (Jonietz, 2002).

Corporate patent activity can be used as an indicator of technological strength (NSB, 2002). Using a classification system developed by the PTO, which divides patents into approximately 370 classes, the types of patents granted for U.S. and foreign inventors can be compared (NSB, 2002). Table 4-3 shows the top five U.S. patent classes emphasized by corporations in the United States and the top foreign inventors patenting in the United States. In 1999, patents granted to U.S. inventors for medical and surgical devices, biotechnology, electronics, and telecommunications indicated U.S. technological strengths in these areas (NSB, 2002). In contrast, U.S. patenting by Japanese inventors reflected that country's emphasis on photocopying, photography, and consumer electronics technology. German inventors were granted U.S. patents for heavy manufacturing, motor vehicles, and new chemistry and advanced materials, while Taiwan's inventors concentrated on semiconductor manufacturing processes and audio systems, and South Korea's emphasized television and computer technologies (NSB, 2002).

Table 4-3. Top Five U.S. Patent Classes Emphasized by Corporations from United States, Japan, Germany, South Korea, and Taiwan: 1999

Country		Patent Class
United States	1.	Surgical instruments
	2.	Biology of multicellular organisms
	3.	Surgery: light, thermal, and electrical applications
	4.	Wells
	5.	Data processing
Japan	1.	Information storage and retrieval
	2.	Television signal processing
	3.	Photocopying
	4.	Electrophotography
	5.	Photography
Germany	1.	Plant protecting and regulating compositions
	2.	Clutches and power-stop controls
	3.	Printing
	4.	Brake systems
	5.	Metal deforming
South Korea	1.	Transmission systems
	2.	Liquid crystal cells, elements and systems
	3.	Refrigeration
	4.	Static information storage and retrieval
	5.	Power-delivery controls
Taiwan	1.	Semiconductor device manufacturing process
	2.	Electrical connectors
	3.	Solid state devices
	4.	Music
	5.	Circuit makers and breakers

SOURCE: RAND, based on NSB, Science and Engineering Indicators—2002

Although it may be tempting to use the number of patents granted as a measure of innovation or productivity of a given industry or field, the propensity to patent inventions varies considerably among different industries and fields, making comparisons of patent rates, and thus any conclusions based on these comparisons, quite difficult (NSB, 2002). For example, the biotechnology industry tends to aggressively patent inventions to protect its innovations, while the software industry mainly relies on copyrights to protect its intellectual property.

The citation of scientific and technical articles and patents provides an indication of the growing link between research and innovation (NSB, 2002). There has been a rapid increase in the incidence of patents citing scientific and technical articles from approximately 22,000 in 1985 to 310,000 in 1998, and then falling slightly in 1999 and 2000 (NSB, 2002). This rapid rise in the number of scientific articles cited in patents is primarily due to huge increases in the number of citations to articles in the fields of biomedical research and clinical medicine (NSB, 2002). In 2000, citations to these two fields accounted for approximately 70 percent of all citations (NSB, 2002).

Of particular interest in the linkage of patent citations to the scientific literature is a CHI Research study of patents granted to U.S. industry, which found that approximately 73 percent of the science articles cited in the patents are publications that resulted from publicly-funded science (Narin, 1998). In other words, 73 percent of the science citations in U.S. industry patents are to scientific publications from universities and colleges, government laboratories, government-funded research and development centers, and other public laboratories (Narin, 1998). The CHI Research study concluded that publicly funded science is having a "major impact on U.S. technology" (Narin, 1998).

In summary, the number of full-time students pursuing graduate degrees at U.S. higher education institutions in S&E fields has declined in the past decade, with enrollments generally paralleling increases and decreases in federal research funding for the various fields of S&E. Meanwhile, the number of S&E doctorates awarded by European and Asian higher education institutions has risen steadily. During the past two decades, the number of foreign-born students pursuing S&E degrees at U.S. higher education institutions has increased markedly, as has the number of foreign-born scientists and engineers employed in the U.S. workforce. With more U.S.-trained, foreign-born scientists and engineers returning to their native lands to work and the median age of the U.S. scientific and engineering workforce increasing each year, there is a pressing need to expand the domestic pipeline of scientists and engineers in the United States.

In the past decade, the number of U.S.-authored S&E articles has declined in most fields, while trends in many other countries are going in the opposite direction. During this same period, the number of patents issued by the United States has more than doubled, largely due to activity in the life sciences and biotechnology, with almost half of the U.S. patents going to foreign inventors. Concomitantly, there is growing evidence supporting the link between government funding for S&E research and the technological innovation that can drive an economy.

CHAPTER 5

PCAST was interested in how R&D funding in the United States compares with that of other major R&D-performing nations, and raised the following issue to obtain information for its deliberations:

> Compare U.S. R&D spending with comparable spending by the European Union, Japan, China, and other major R&D-performing nations.

International Comparisons

The United States has led the major R&D-performing nations for the last 20 years in terms of absolute levels of R&D spending (NSB, 2002).[16] Since 1994, U.S. total R&D spending has steadily increased at a rate of approximately 6 percent a year (NSB, 2002). In 1999, the most recent year for which there are data for all of the G-7 countries,[17] the United States spent $245 billion on R&D activities—over 150 percent more than Japan ($95 billion), the second-largest R&D-performing country, and over 55 percent more than the entire European Union ($158 billion) (Table 5-1) (OECD, 2001). Furthermore, in inflation-adjusted purchasing power parity (PPP) dollars, U.S. R&D expenditures exceeded the combined total expenditures of the other G-7 countries and accounted for 44 percent of the OECD countries' R&D expenditures in 1999 (Figure 5-1 and Table 5-1; also see Appendix Table 24).[18] In 2000, U.S. total R&D spending increased to $265 billion (OECD, 2001).

In terms of relative shares, U.S. R&D spending in 1985 reached historical highs of 53 percent of the G-7 total and 48 percent of all OECD R&D (NSB, 2002). R&D spending worldwide slowed for several years in the early to mid-1990s, mainly due to economic recessions and general budgetary constraints that slowed both industrial and government sources of R&D support (NSB, 2002). By 1992, U.S. R&D spending had dropped to 49 percent of the G-7 total, and by 1995 it had dropped to 42 percent of the OECD R&D total (NSB, 2002). However in the past few years, R&D spending has rebounded in several countries. R&D spending in the United States has generally been stronger than elsewhere, thus increasing the U.S. share of both G-7 and OECD countries' R&D spending (NSB, 2002). By 1999, U.S. R&D had climbed to 52 percent of the G-7 total ($471 billion) and 44 percent of the OECD total ($558 billion).

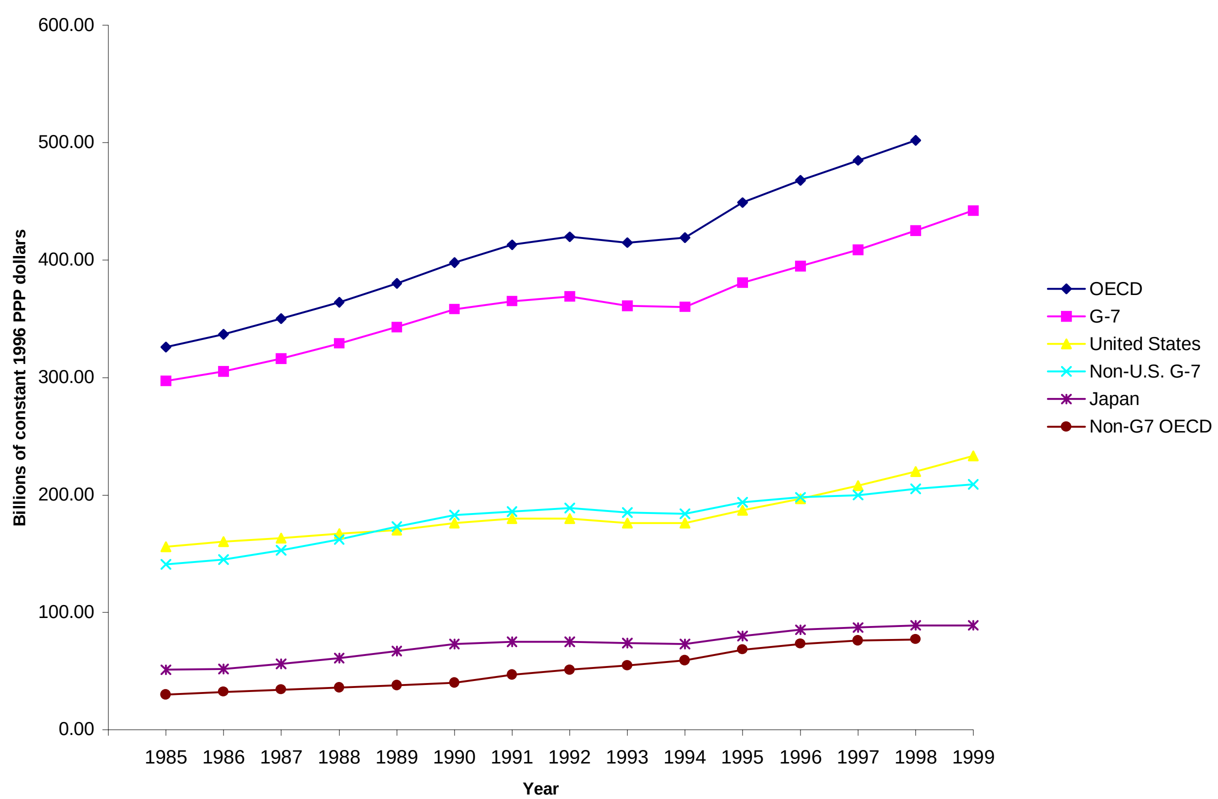
[16] Unless otherwise noted, all R&D spending levels are converted to U.S. dollars using purchasing power parity (PPP)exchange rates.
[17] The G-7 countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.
[18] Current OECD members are Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, South Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

Table 5-1. Gross Domestic Expenditure on R&D, G-7 and Other Selected Countries
(millions of current PPP dollars)

	1994	1995	1996	1997	1998	1999	2000
United States	**169,270.0**	**184,306.0**	**197,830.0**	**213,038.0**	**227,350.0**	**244,699.0**	**265,318.0**
Japan	75,287.2	84,783.3	85,469.6	89,632.5	93,119.6	95,084.6	NA
Germany	37,028.5	39,451.5	39,902.3	41,751.5	43,393.3	47,573.6	50,387.8
China	18,326.2	19,332.2	21,361.1	26,751.0	29,356.2	37,614.0	NA
France	26,517.1	27,722.6	27,783.8	27,084.8	27,758.2	29,239.9	30,192.5
United Kingdom	21,765.1	21,672.5	22,467.8	22,718.6	23,920.0	25,463.4	NA
South Korea	12,771.4	15,345.7	17,287.5	19,000.0	17,037.0	18,543.0	NA
Canada	10,693.0	11,697.5	11,749.2	12,499.6	13,856.9	14,727.3	16,094.7
Italy	11,343.7	11,522.8	12,100.8	11,913.4	12,621.8	13,830.3	NA
Russia	8,371.2	7,775.2	8,780.2	9,684.1	8,998.5	10,783.7	12,724.7
Taiwan	NA	6,508.0	7,047.7	7,884.6	8,608.1	9,570.4	NA
European Union	**124,561.6**	**131,034.6**	**135,150.3**	**138,613.8**	**145,483.7**	**157,641.0**	**NA**
Total OECD	**402,577.0**	**442,543.3**	**470,013.8**	**496,756.0**	**522,427.0**	**557,683.0**	**NA**

NA = Not Available
G-7 Countries are Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.
SOURCE: RAND, based on OECD, Main Science and Technology Indicators: 2001-2 Edition.

Figure 5-1. U.S., G-7, and OECD Countries' R&D Expenditures



SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

Another indicator of a country's commitment to growth in science and technology is the ratio of R&D spending to the GDP (NSB, 2002). According to the most-recent data from the OECD,[19] the United States ranks fifth among OECD countries in terms of reported R&D-to-GDP ratios (see Table 5-2) (OECD, 2001). Sweden has the highest R&D-to-GDP ratio, followed by Finland, Japan, and Switzerland. Other large R&D performers in the OECD, including South Korea, Germany, France, the United Kingdom, Canada, and Italy, all invest smaller shares of their GDP in R&D than the United States. Of the non-OECD member countries, Israel's and Taiwan's nondefense R&D-to-GDP ratios compare favorably with those of the OECD member countries, with Israel ranking seventh in the world and Taiwan ranking twelfth. Although China and Russia spend a lot in absolute terms on R&D, their investments in R&D as shares of their GDPs are substantially lower than that of the United States.

Table 5-2. Total R&D as a Percent of Gross Domestic Product (GDP)

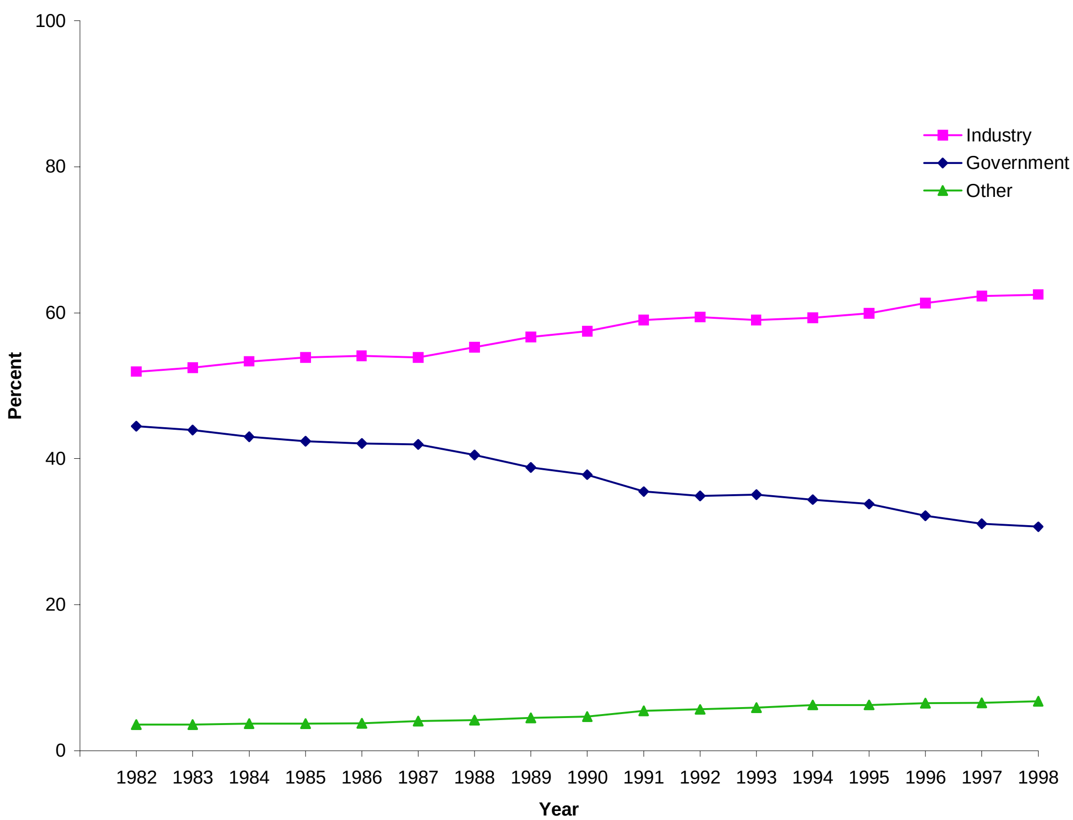
Sweden (1999)	3.80	Brazil (1996)	0.91
Finland (1999)	3.22	Spain (1999)	0.89
Japan (1999)	2.93	Cuba (1999)	0.83
Switzerland (1996)	2.73	China (1999)	0.83
United States (1999)	**2.65**	Portugal (1999)	0.76
Israel (1997)	2.54	Poland (1999)	0.75
South Korea (1999)	2.47	South Africa (1998)	0.69
Germany (1999)	2.44	Hungary (1999)	0.69
Iceland (1999)	2.32	Slovak Republic (1999)	0.68
France (1999)	2.19	Greece (1999)	0.68
Denmark (1999)	2.06	Chile (1997)	0.63
Netherlands (1999)	2.05	Turkey (1999)	0.63
Taiwan (1999)	2.05	Argentina (1999)	0.47
Belgium (1999)	1.98	Romania (1999)	0.41
United Kingdom (1999)	1.87	Colombia (1997)	0.41
Singapore (1999)	1.87	Mexico (1999)	0.40
Canada (1999)	1.85	Panama (1998)	0.33
Austria (1999)	1.83	Bolivia (1999)	0.29
Norway (1999)	1.70	Uruguay (1999)	0.26
Slovenia (1999)	1.51	Malaysia (1996)	0.22
Australia (1998)	1.50	Trinidad and Tobago (1997)	0.14
Ireland (1997)	1.39	Nicaragua (1997)	0.13
Czech Republic (1999)	1.25	Ecuador (1998)	0.08
Costa Rica (1996)	1.13	El Salvador (1998)	0.08
New Zealand (1997)	1.13	Peru (1997)	0.06
Italy (1999)	1.03	**European Union** (1999)	1.86
Russian Federation (1999)	1.01	**Total OECD** (1999)	2.21

NOTE: Data presented are for latest available year (shown in parentheses).
Data for Israel and Taiwan represent these countries' nondefense R&D/GDP ratio.
SOURCE: RAND, based on OECD, Main Science and Technology Indicators: 2001–2 Edition; and NSB, Science & Engineering Indicators—2002.

[19]The data in this report are based on the most-recent edition of OECD's "Main Science and Technology Indicators" (2001-2 Edition), which was published in November 2001.

Industry investment in R&D has accounted for the dominant share of R&D spending in the OECD countries for the last 20 years, increasing from 52 percent in 1982 to 63 percent in 1998 (Figure 5-2; also see Appendix Table 25). Concurrent with this rise in industry spending on R&D was a relative decline in government funding of R&D, from 45 percent in 1982 to 31 percent in 1998. In all but one of the G-7 countries (Russia is not a G-7 country), industry was the leading funder of R&D (Figure 5-3; also see Appendix Table 26). In comparison, government funded the majority of R&D in Italy and Russia. In contrast, government was the primary funder of academic R&D in all the G-8[20] countries (Figure 5-3; also see Appendix Table 27). However, it is important to note that, in each of the G-7 countries, the government share of funding for academic R&D has declined over the past 20 years, as industry funding for academic R&D has increased (see Appendix Table 27).

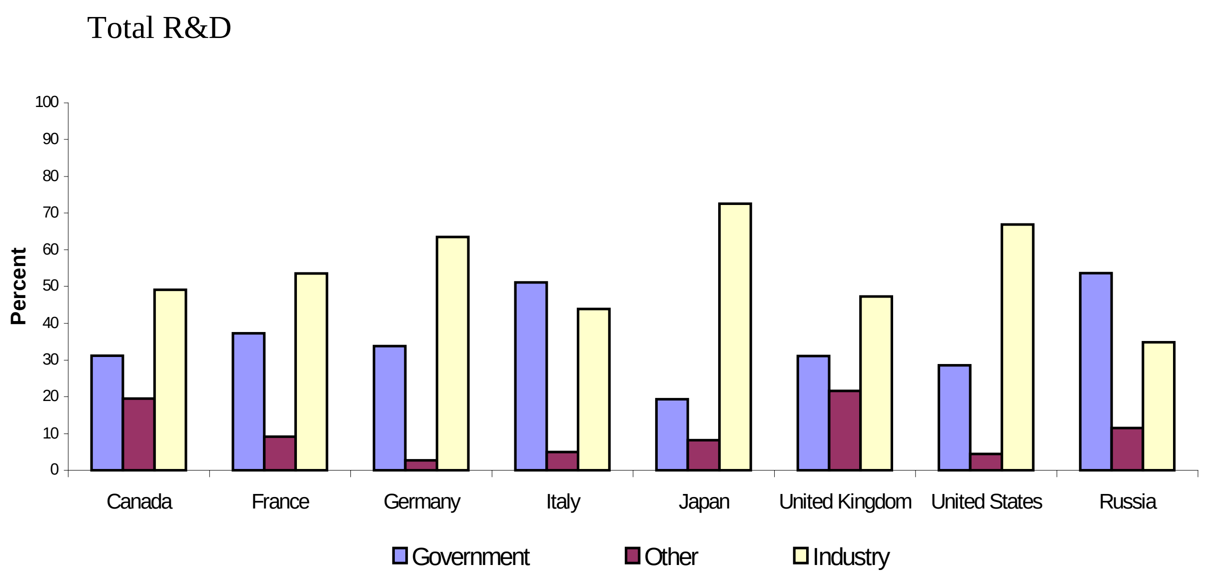
Figure 5-2. Sources of R&D Expenditures in OECD Countries

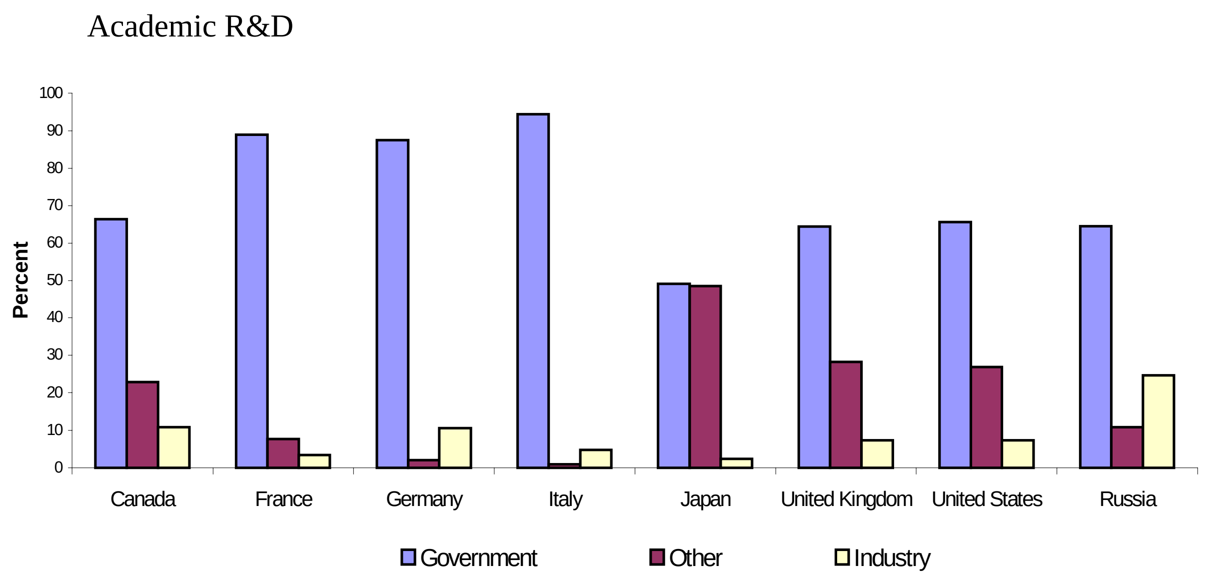


SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

[20]When Russia is included with the G-7 countries, this is usually referred to as the "G-8 countries."

Figure 5-3. R&D Expenditures, by Country and Source of Funds





SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

The primary objectives of R&D supported by governments vary considerably between countries (Figure 5-4; also see Appendix Table 28). In 1999, the U.S. government spent the majority of its R&D funds on defense, investing a larger share in defense than any other country. This dominance of U.S.-funded defense R&D was evident, even though there has been a steady decline in U.S. defense R&D spending since the mid-1980s—down from 69 percent in 1986 to 53 percent in 1999 (NSB, 2002). The U.S. government also spent a sizable share of its R&D dollars on health-related R&D. The other G-8 countries tended to emphasize R&D for the advancement of knowledge and economic development.

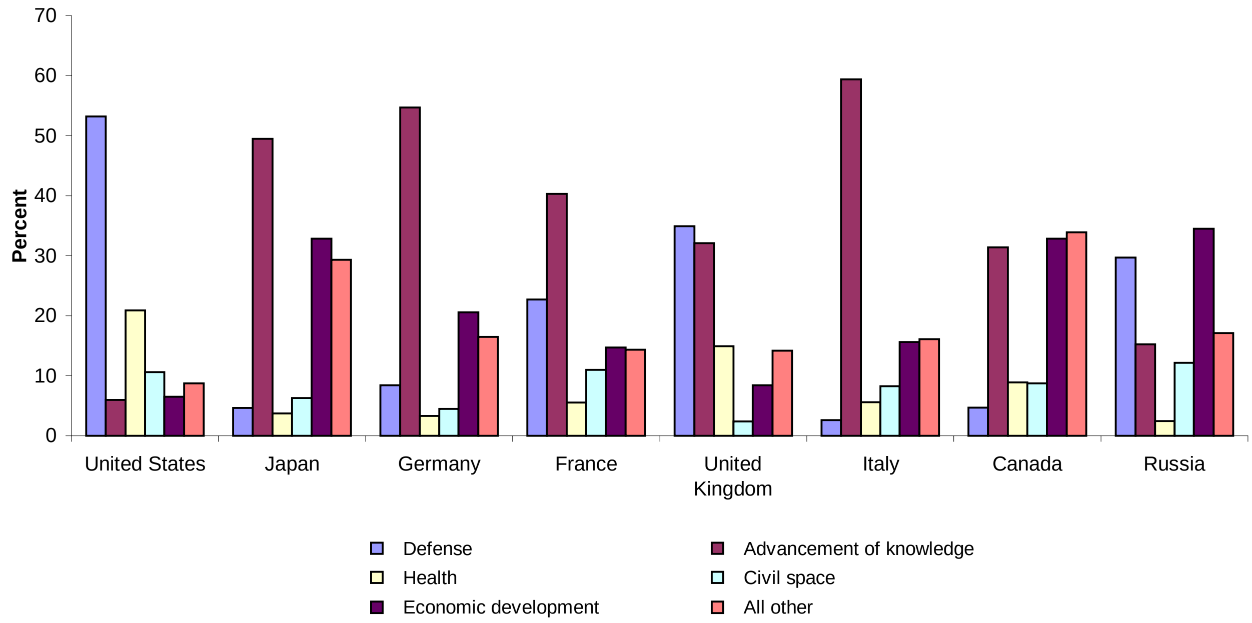
Japan, Germany, and Italy all spent 50 percent or more of their government R&D funds on the advancement of knowledge, which includes support for both advancement of research and general university funds (Figure 5-4).[21] In fact, the general university funds portion of the advancement of knowledge category is the largest part of government R&D expenditures for most OECD countries (NSB, 2002). In comparison, the United States spent only 6 percent of its government R&D funds on the advancement of knowledge, mainly through funding of non-mission-oriented R&D by NSF and the DOE Office of Science.[22] The majority of government-supported R&D at U.S. universities and colleges is mission oriented; R&D funds being allocated and awarded by federal agencies as research grants to address specific national goals and objectives, such as space exploration and defense, for which each agency is responsible.

Japan, Canada, and Russia all spent more than 30 percent of their government R&D funds on economic development activities (Figure 5-4).[23] Japan spent 19 percent of its total government R&D funds on energy related activities. Canada spent 13 percent of its total government funds on industrial development and 11 percent on agricultural activities. In Russia, industrial development is the leading socioeconomic objective, accounting for 23 percent of all government R&D (see Appendix Table 25). In contrast, industrial R&D accounted for less than 1 percent of government R&D in the United States, most of which was funded by the National Institute of Standards and Technology (NIST) of the Department of Commerce.

In the past two decades, the United States has led the world in total spending on R&D. At present, however, four other nations spend more of their GDP on R&D than does the United States In all of these nations, including the United States, industry-funded R&D outpaced government-funded R&D, with the latter being the major source of funds for academic R&D in all G-8 nations. The main objective of government-funded R&D differs markedly among G-8 nations, however, with defense driving most of the government-funded R&D in the United States. In other G-8 nations, the advancement of knowledge and economic development dominated government-funded R&D.

[21]General university funds are block grants provided by government to the academic sector that can be spent at the discretion of the university on research of its choosing. Neither the United States nor Russia has a category equivalent to general university funds.
[22]The United States defines the advancement of knowledge as research unrelated to a specific national objective.
[23]Economic development programs include the promotion of agriculture, fisheries and forestry, industry, infrastructure, and energy.

Figure 5-4. Government R&D Support by Primary Objectives, G-8 Countries



NOTE: Data for Italy, Russia, and Canada are for 1998; data for all other countries are for 1999.
SOURCE: RAND, based on NSB, Science & Engineering Indicators—2002

APPENDIX I.
SUPPORTING TABLES

APPENDIX TABLES

SUPPORTING TABLES FOR USER NOTES

SUPPORTING TABLES
FOR
USER NOTES

Table 1. Detailed Fields of Science and Engineering

Broad Field	Detailed Field	Illustrative Disciplines
Life sciences	biological	anatomy; biochemistry; biology; biometry and biostatistics; biophysics; botany; cell biology; entomology and parasitology; genetics; micro- biology; neuroscience (biological); nutrition; physiology; zoology; other biological, n.e.c.
	environmental biology	ecosystem sciences; evolutionary biology; limnology; physiological ecology; population and biotic community ecology; population biology; systematics; other environmental biology, n.e.c.
	agricultural	agronomy; animal sciences; food science and technology; fish and wildlife; forestry; horticulture; phytopathology; phytoproduction; plant sciences; soils and soil science; general agriculture; other agriculture, n.e.c.
	medical	dentistry; internal medicine; neurology; obstetrics and gynecology; ophthalmology; otolaryngology; pathology; pediatrics; pharmacology; pharmacy; preventive medicine; psychiatry; radiology; surgery; veterinary medicine; other medical, n.e.c.
	life sciences, n.e.c.	
Psychology	biological aspects	animal behavior; clinical psychology; comparative psychology; ethology; experimental psychology
	social aspects	development and personality; educational, personnel, and vocational psychology and testing; industrial and engineering psychology; social psychology
	psychological sciences, n.e.c.	
Physical sciences	astronomy	laboratory astrophysics; optical astronomy; radio astronomy; theoretical astrophysics; X-ray, gamma-ray, and neutrino astronomy
	chemistry	inorganic; organic; organometallic; physical
	physics	acoustics; atomic and molecular; condensed matter; elementary particle; nuclear structure; optics; plasma
	physical sciences, n.e.c.	
Environmental sciences	atmospheric sciences	aeronomy; extraterrestrial atmospheres; meteorology; solar; weather modification
	geological sciences	engineering geophysics; general geology; geodesy and gravity; geomagnetism; hydrology; inorganic geochemistry; isotopic geochemistry; laboratory geophysics; organic geochemistry; paleomagnetism; paleontology; physical geography and cartography; seismology; soil sciences
	oceanography	biological oceanography; chemical oceanography; marine geophysics; physical oceanography
	environmental sciences, n.e.c.	
Mathematics and computer sciences	mathematics	algebra; analysis; applied mathematics; foundations and logic; geometry; numerical analysis; statistics; topology
	computer sciences	computer and information sciences (general); design, development, and application of computer capabilities to data storage and manipulation; information sciences and systems; programming languages; systems analysis
	mathematics and computer sciences, n.e.c.	

Table 1. Detailed Fields of Science and Engineering (continued)

Broad Field	Detailed Field	Illustrative Disciplines
Engineering	aeronautical	aerodynamics
	astronautical	aerospace; space technology
	chemical	petroleum; petroleum refining; process
	civil	architectural; hydraulic; hydrologic; marine; sanitary and environmental; structural; transportation
	electrical	communication; electronic; power
	mechanical	engineering mechanics
	metallurgy and materials	ceramic; mining; textile; welding
	engineering, n.e.c.	agricultural; bioengineering; biomedical; industrial and management; nuclear; ocean; systems
Social sciences	anthropology	applied anthropology; archaeology; cultural and personality; social and ethnology
	economics	economic systems and development; econometrics and economic statistics; history of economic thought; industrial, labor, and agricultural economics; international economics; macroeconomics; microeconomics; public finance and fiscal policy; theory
	political science	area or regional studies; comparative government; history of political ideas; international relations and law; national political and legal systems; political theory; public administration
	sociology	comparative and historical; complex organizations; culture and social structure; demography; group interactions; social problems and social welfare; sociological theory
	social sciences, n.e.c.	linguistics; research in education; research in history; research in law (e.g., attempts to assess impact on society of legal systems and practices); socioeconomic geography
Other sciences, n.e.c.:		multidisciplinary or interdisciplinary projects that cannot be classified within one of the broad fields of science already listed.

n.e.c. = not elsewhere classified

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Studies, Federal Funds for Research and Development: Fiscal Years 1999, 2000, and 2001

Table 2. NIH Obligations for Research by Detailed Field of Science and Engineering: FY 1999 and FY 2000
[in millions of constant FY 2000 dollars]

Field of science & engineering	1999	2000	Percent change 1999–2000
Total, all fields	13141.0	16918.3	28.7%
Life sciences, total	11409.2	13317.1	16.7%
Biol (excl environmental)	5227.5	9398.7	79.8%
Environmental biology	0.1	0.0	-100.0%
Agricultural	0.0	0.0	0.0%
Medical sciences, total	5575.5	3128.7	-43.9%
Life sciences, n.e.c.	375.6	789.8	110.3%
Psychology, total	489.0	1463.7	199.3%
Biological aspects	15.0	0.0	-100.0%
Social aspects	7.4	0.0	-100.0%
Psychological sci, n.e.c.	466.7	1463.7	213.7%
Physical sciences, total	208.1	610.8	193.5%
Astronomy	0.0	0.0	0.0%
Chemistry	184.8	594.3	221.7%
Physics	23.4	0.0	-100.0%
Physical sciences, n.e.c.	0.0	16.4	>1000%
Environmental sciences, total	40.2	361.9	800.6%
Atmospheric sciences	0.0	0.0	0.0%
Geological sciences	0.0	0.0	0.0%
Oceanography	0.0	0.0	0.0%
Environmental sci, n.e.c.	40.2	361.9	800.6%
Math & computer sci, total	118.3	125.8	6.4%
Mathematics	55.1	125.8	128.4%
Computer sciences	63.2	0.0	-100.0%
Math & computer sci, n.e.c.	0.0	0.0	0.0%
Engineering, total	190.2	385.1	102.5%
Aeronautical	0.0	0.0	0.0%
Astronautical	0.0	0.0	0.0%
Chemical	0.0	0.0	0.0%
Civil	0.0	0.0	0.0%
Electrical	0.0	0.0	0.0%
Mechanical	0.0	0.0	0.0%
Metallurgy & materials	0.0	52.1	>1000%
Engineering, n.e.c.	190.2	332.9	75.0%
Social sciences, total	121.8	232.6	90.9%
Anthropology	0.0	0.0	0.0%
Economics	0.0	0.0	0.0%
Political science	0.0	0.0	0.0%
Sociology	0.3	0.0	-100.0%
Social sciences, n.e.c.	121.5	232.6	91.4%

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002.

SUPPORTING TABLES
FOR
PCAST ISSUE 1

Federal R&D

Table 3. Trends in Federal R&D by Agency and Mission, FY 1976–2003
[budget authority in billions of current dollars]

	DOD S&T*	NASA	DOE	NIH	NSF	Other**	Total R&D***	R&D by Mission	
								Defense^	Non-Defense^^
1976	2.1	3.5	3.1	2.3	0.7	2.5	22.1	11.1	11.0
1977	2.2	3.8	4.2	2.5	0.7	2.6	25.3	12.5	12.8
1978	2.3	4.0	5.1	2.8	0.8	3.1	27.8	13.3	14.5
1979	2.5	4.6	5.4	3.2	0.8	3.4	30.5	14.3	16.2
1980	2.9	5.2	5.8	3.4	0.9	3.7	33.0	15.4	17.6
1981	3.2	5.5	6.2	3.6	1.0	3.8	37.3	19.0	18.3
1982	3.7	4.6	5.4	3.7	1.0	3.2	38.7	22.9	15.8
1983	4.1	2.7	5.2	4.1	1.1	3.4	40.0	25.6	14.4
1984	4.4	3.0	5.6	4.6	1.2	3.6	46.0	30.5	15.5
1985	5.9	3.6	6.0	5.3	1.4	3.5	51.7	34.7	17.0
1986	7.3	3.7	5.5	5.4	1.4	3.5	54.6	37.6	17.0
1987	8.3	4.3	5.4	6.4	1.5	3.8	58.6	39.8	18.8
1988	8.7	4.7	5.8	6.9	1.6	3.9	61.0	41.0	20.1
1989	9.3	5.9	6.3	7.6	1.8	4.2	64.3	41.6	22.7
1990	6.2	7.1	7.0	8.1	1.7	4.6	66.4	41.0	25.5
1991	7.3	8.1	7.3	9.0	1.9	5.2	68.7	40.4	28.4
1992	7.2	8.5	8.1	9.6	2.0	5.9	71.9	41.2	30.7
1993	8.7	8.8	7.4	9.9	2.0	5.9	72.9	42.1	30.8
1994	8.3	9.4	6.8	10.5	2.2	6.7	71.1	38.3	32.8
1995	7.9	9.5	6.4	10.8	2.4	6.6	70.9	37.8	33.1
1996	7.5	9.4	6.3	11.4	2.4	5.9	71.2	38.5	32.7
1997	7.5	9.4	6.2	12.2	2.4	6.5	73.9	40.0	33.9
1998	7.7	9.8	6.4	13.1	2.5	6.7	75.9	40.6	35.4
1999	7.6	9.7	7.0	15.0	2.7	6.9	80.2	42.1	38.1
2000	8.6	9.5	7.0	17.2	2.9	7.2	83.8	43.2	40.6
2001	9.4	9.9	7.7	19.8	3.3	8.0	91.5	46.2	45.3
2002	10.3	10.2	8.4	22.8	3.5	8.6	103.1	53.5	49.7
2003	10.0	10.7	8.3	26.5	3.7	8.1	112.0	58.8	53.3

Source: AAAS Reports I–XXVII based on OMB and agency R&D budget data.
Include conduct of R&D and R&D Facilities.
* DOD S&T represents categories “6.1”–“6.3” but excludes weapons development.
** Excludes DOD weapons development.
*** Includes all development.
^ Includes DOD and defense R&D in DOE.
^^ Includes all R&D not in defense.

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work
[budget authority in millions of dollars]

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Change FY 02-03 Percent
TOTAL R&D (Conduct of R&D and R&D Facilities)					
Defense (military)	42,740	49,639	**54,827**	5,188	10.5%
S&T (6.1-6.3 + medical)	*9,365*	*10,341*	***9,957***	*-384*	*-3.7%*
All Other DOD R&D	*33,375*	*39,298*	***44,870***	*5,572*	*14.2%*
Health and Human Services	21,045	24,141	**27,551**	3,410	14.1%
Nat'l Institutes of Health	*19,807*	*22,795*	***26,452***	*3,657*	*16.0%*
NASA	9,887	10,232	**10,676**	444	4.3%
Energy	7,733	8,361	**8,323**	-38	-0.5%
Nat'l Science Foundation	3,320	3,526	**3,651**	125	3.5%
Agriculture	2,181	2,334	**2,118**	-216	-9.3%
Commerce	1,030	1,096	**1,100**	4	0.3%
NOAA	*561*	*611*	***605***	*-6*	*-1.1%*
NIST	*413*	*460*	***483***	*23*	*5.0%*
Interior	621	660	**628**	-32	-4.8%
Transportation	718	778	**736**	-42	-5.4%
Environ. Protection Agency	574	592	**627**	35	5.9%
Veterans Affairs	719	761	**810**	49	6.5%
Education	264	268	**311**	43	16.0%
Int'l Assistance Programs	252	268	**182**	-86	-32.1%
Smithsonian	121	126	**131**	5	4.0%
Tennessee Valley Auth.	29	30	**30**	0	0.0%
Labor	17	20	**10**	-10	-50.0%
Nuclear Reg. Comm.	53	61	**68**	7	11.5%
Corps of Engineers	27	27	**27**	0	0.0%
Housing and Urban Dev.	53	47	**47**	0	0.0%
Justice	88	98	**114**	16	16.3%
Social Security	30	37	**30**	-7	-18.9%
Postal Service	29	46	**47**	1	2.2%
Treasury	3	3	**3**	0	0.0%
Total R&D	91,534	103,150	**112,047**	8,897	8.6%
Defense R&D	46,202	53,478	**58,774**	5,297	9.9%
Nondefense R&D	45,332	49,672	**53,273**	3,601	7.2%

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work (continued)
[budget authority in millions of dollars]

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Change FY 02-03 Percent
BASIC RESEARCH					
Defense (military)	1,287	1,376	**1,365**	-11	-0.8%
Health and Human Services	11,642	13,193	**14,379**	1,185	9.0%
Nat'l Institutes of Health	*11,639*	*13,190*	***14,376***	*1,185*	*9.0%*
NASA	1,695	1,967	**2,361**	395	20.1%
Energy	2,390	2,424	**2,519**	94	3.9%
Nat'l Science Foundation	2,852	3,058	**3,205**	147	4.8%
Agriculture	801	860	**880**	20	2.3%
Commerce	50	52	**73**	21	40.4%
NOAA	*0*	*0*	***0***	*0*	- -
NIST	*50*	*52*	***73***	*21*	*40.4%*
Interior	56	58	**55**	-3	-4.4%
Transportation	17	13	**25**	12	92.6%
Environ. Protection Agency	104	107	**101**	-6	-5.3%
Veterans Affairs	289	329	**351**	23	6.9%
Education	2	2	**1**	-1	-50.0%
Int'l Assistance Programs	50	53	**39**	-14	-26.4%
Smithsonian	108	111	**114**	3	2.7%
Tennessee Valley Auth.	0	0	**0**	0	- -
Labor	2	2	**2**	0	0.0%
Corps of Engineers	3	3	**3**	0	0.0%
Justice	27	27	**25**	-2	-7.4%
Total BASIC RESEARCH	21,376	23,635	**25,499**	1,864	7.9%
Defense	1,303	1,392	**1,383**	-10	-0.7%
Nondefense	20,073	22,243	**24,116**	1,874	8.4%

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work (continued)
[budget authority in millions of dollars]

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Percent
APPLIED RESEARCH					
Defense (military; incl. Med.)	4,106	4,550	**3,847**	-703	-15.4%
Health and Human Services	9,094	10,416	**12,258**	1,842	17.7%
Nat'l Institutes of Health	*7,923*	*9,156*	***11,203***	*2,047*	*22.4%*
NASA	2,599	2,857	**3,188**	330	11.6%
Energy	2,306	2,731	**2,669**	-62	-2.3%
Nat'l Science Foundation	180	192	**199**	7	3.7%
Agriculture	1,044	986	**946**	-40	-4.1%
Commerce	775	835	**810**	-25	-3.0%
NOAA	*511*	*546*	***546***	*0*	*0.0%*
NIST	*256*	*282*	***255***	*-27*	*-9.5%*
Interior	534	570	**541**	-29	-5.1%
Transportation	444	503	**481**	-22	-4.4%
Environ. Protection Agency	369	383	**430**	47	12.3%
Veterans Affairs	415	417	**442**	26	6.1%
Education	172	178	**212**	34	19.1%
Int'l Assistance Programs	199	215	**143**	-72	-33.5%
Smithsonian	0	0	**0**	0	- -
Tennessee Valley Auth.	15	15	**15**	0	0.0%
Labor	15	18	**8**	-10	-55.6%
Nuclear Reg. Comm.	53	61	**68**	7	11.5%
Corps of Engineers	14	14	**14**	0	0.0%
Housing and Urban Dev.	53	47	**47**	0	0.0%
Justice	31	22	**20**	-2	-9.1%
Social Security	30	37	**30**	-7	-18.9%
Treasury	3	3	**3**	0	0.0%
Total APPLIED RESEARCH	22,451	25,050	**26,370**	1,320	5.3%
Defense	5,786	6,526	**5,924**	-602	-9.2%
Nondefense	16,665	18,524	**20,447**	1,923	10.4%

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work (continued)
[budget authority in millions of dollars] Page 4 of 6

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Percent
Total RESEARCH (basic + applied)					
Defense (military; incl. Med.)	5,393	5,926	**5,213**	-713	-12.0%
Health and Human Services	20,735	23,610	**26,636**	3,027	12.8%
Nat'l Institutes of Health	*19,561*	*22,346*	***25,578***	*3,232*	*14.5%*
NASA	4,294	4,824	**5,549**	725	15.0%
Energy	4,697	5,155	**5,188**	32	0.6%
Nat'l Science Foundation	3,032	3,250	**3,404**	154	4.7%
Agriculture	1,845	1,846	**1,826**	-20	-1.1%
Commerce	825	887	**883**	-4	-0.4%
NOAA	*511*	*546*	***546***	*0*	*0.0%*
NIST	*306*	*334*	***328***	*-6*	*-1.8%*
Interior	590	628	**596**	-32	-5.1%
Transportation	461	517	**506**	-10	-2.0%
Environ. Protection Agency	474	489	**531**	41	8.5%
Veterans Affairs	704	745	**794**	48	6.5%
Education	174	180	**213**	33	18.3%
Int'l Assistance Programs	249	268	**182**	-86	-32.1%
Smithsonian	108	111	**114**	3	2.7%
Tennessee Valley Auth.	15	15	**15**	0	0.0%
Labor	17	20	**10**	-10	-50.0%
Nuclear Reg. Comm.	53	61	**68**	7	11.5%
Corps of Engineers	17	17	**17**	0	0.0%
Housing and Urban Dev.	53	47	**47**	0	0.0%
Justice	58	49	**45**	-4	-8.2%
Social Security	30	37	**30**	-7	-18.9%
Treasury	3	3	**3**	0	0.0%
Total RESEARCH	43,826	48,685	**51,869**	3,184	6.5%
Defense	7,088	7,918	**7,306**	-612	-7.7%
Nondefense	36,738	40,767	**44,563**	3,796	9.3%

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work (continued)
[budget authority in millions of dollars] Page 5 of 6

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Change FY 02-03 Percent
DEVELOPMENT					
Defense (military)	37,326	43,703	**49,593**	5,890	13.5%
S&T (6.3 Development)	*3,972*	*4,415*	***4,745***	*330*	*7.5%*
All Other DOD Develop.	*33,354*	*39,288*	***44,848***	*5,560*	*14.2%*
Health and Human Services	45	62	**28**	-34	-54.8%
Nat'l Institutes of Health	*0*	*0*	***0***	*0*	*- -*
NASA	2,768	2,667	**2,723**	56	2.1%
Energy	1,965	2,061	**2,062**	1	0.0%
Nat'l Science Foundation	0	0	**0**	0	- -
Agriculture	152	163	**156**	-7	-4.3%
Commerce	139	132	**80**	-52	-39.6%
NOAA	*23*	*28*	***29***	*1*	*2.0%*
NIST	*69*	*87*	***49***	*-38*	*-43.7%*
Interior	32	32	**32**	0	-0.2%
Transportation	243	244	**210**	-34	-13.9%
Environ. Protection Agency	100	102	**96**	-6	-6.3%
Veterans Affairs	14	15	**16**	1	6.4%
Education	90	88	**98**	10	11.4%
Int'l Assistance Programs	3	0	**0**	0	- -
Tennessee Valley Auth.	14	15	**15**	0	0.0%
Corps of Engineers	10	10	**10**	0	0.0%
Justice	30	49	**69**	20	40.8%
Postal Service	29	46	**47**	1	2.2%
Total Development	42,959	49,390	**55,235**	5,845	11.8%
Defense	38,624	45,003	**50,952**	5,949	13.2%
Nondefense	4,334	4,386	**4,283**	-104	-2.4%

Table 4. R&D in the FY 2003 Budget by Agency and Character of Work (continued)
[budget authority in millions of dollars] Page 6 of 6

	FY 2001 Actual	FY 2002 Estimate	**FY 2003 Budget**	Change FY 02-03 Amount	Percent
R&D Facilities and Capital Equipment					
Defense (military)	21	10	**22**	12	120.0%
Health and Human Services	265	469	**887**	418	89.0%
Nat'l Institutes of Health	*246*	*449*	***874***	*425*	*94.6%*
NASA	2,826	2,741	**2,404**	-337	-12.3%
Energy	1,072	1,145	**1,073**	-71	-6.2%
Nat'l Science Foundation	288	276	**247**	-29	-10.4%
Agriculture	184	325	**136**	-189	-58.2%
Commerce	66	77	**137**	60	77.9%
NOAA	*27*	*37*	***30***	*-7*	*-18.9%*
NIST	*38*	*39*	***106***	*67*	*171.8%*
Transportation	15	17	**19**	2	11.5%
Smithsonian	13	15	**17**	2	13.3%
Total R&D Facils.	4,749	5,075	**4,943**	-132	-2.6%
Defense	489	556	**516**	-40	-7.3%
Nondefense	4,260	4,519	**4,427**	-92	-2.0%

NOTE: The projected inflation rate between FY 2002 and FY 2003 is 1.8 percent.
All years include homeland security and other emergency appropriations.
All years adjusted to include proposals to fully fund federal retiree costs.
All figures are rounded to the nearest million.
Changes calculated from unrounded figures.

SOURCE: AAAS, based on OMB data for R&D for FY 2003, agency budget justifications, and information from agency budget offices.

Table 5. FS&T and R&D in the FY 2003 Budget by Agency
[budget authority in millions of dollars]

	FY 2003 R&D	**FY 2003 FS&T**
Defense (military)	54,827	**4,952**
S&T (6.1-6.3 + medical)	*9,957*	***4,952***
All Other DOD R&D	*44,870*	***0***
Health and Human Services	27,551	**27,335**
Nat'l Institutes of Health	*26,452*	***27,335***
NASA	10,676	**8,774**
Energy	8,323	**5,027**
Nat'l Science Foundation	3,651	**5,036**
Agriculture	2,118	**1,913**
Commerce	1,100	**861**
NOAA	*605*	***297***
NIST	*483*	***564***
Interior	628	**904**
Transportation	736	**548**
Environ. Protection Agency	627	**797**
Veterans Affairs	810	**409**
Education	311	**431**
Int'l Assistance Programs	182	**0**
Smithsonian	131	**0**
Tennessee Valley Auth.	30	**0**
Labor	10	**0**
Nuclear Reg. Comm.	68	**0**
Corps of Engineers	27	**0**
Housing and Urban Dev.	47	**0**
Justice	114	**0**
Social Security	30	**0**
Postal Service	47	**0**
Treasury	3	**0**
Total R&D	112,047	**56,987**
Defense	58,774	**4,952**
Nondefense	53,273	**52,035**

FS&T: Budget of the U.S. Government FY 2003: Analytical Perspectives, Chapter 8. See "Definitions" section for more on R&D and FS&T.
Includes homeland security and other emergency appropriations.
Adjusted to include proposals to fully fund federal retiree costs.
All figures are rounded to the nearest million.

Source: R&D: AAAS, based on OMB data for R&D for FY 2003, agency budget justifications, and information from agency budget offices.

Table 6. Interagency Science and Technology Initiatives
[budget authority in millions]

	FY 2001 Actual	FY 2002 Estimate	FY 2003 Budget	Change FY 02-03	
				Amount	Percent
National Nanotechnology Initiative					
National Science Foundation	150	199	221	22	11%
Defense	125	180	201	21	12%
Energy	88	91	139	48	53%
NASA	22	46	51	5	11%
Commerce (NIST)	33	38	44	6	16%
National Institutes of Health	40	41	43	2	6%
Other (EPA, DOT, Justice)	8	10	11	1	10%
Total Nanotechnology	466	604	710	106	18%
National and Information Technology R&D					
Commerce	38	43	42	-1	-2%
Defense	310	320	306	-14	-4%
Energy	326	312	313	1	0%
Environ. Protection Agency	4	2	2	0	0%
Health and Human Services	277	310	336	26	8%
NASA	177	181	213	32	18%
National Science Foundation	636	676	678	2	0%
Total IT R&D	1,768	1,844	1,890	46	2%
U.S. Global Change Research Program					
National Science Foundation	181	188	188	0	0%
Energy	116	120	126	6	5%
Commerce (NOAA)	93	100	100	0	0%
Agriculture	51	56	66	10	18%
Interior	27	28	28	0	0%
Environ. Protection Agency	23	21	22	1	5%
Health and Human Services	54	60	68	8	13%
Smithsonian	7	7	7	0	0%
NASA	1,176	1,090	1,109	19	2%
Total USGCRP	1,728	1,670	1,714	44	3%

Source: OMB supporting data for FY 2003 Budget.

Table 7. Federal Counterterrorism R&D, including Weapons of Mass Destruction Congressional Action on R&D in the FY 2002 Budget
(final appropriations Dec. 26, 2001)
[budget authority in millions of dollars]

	FY 2000 Actual	FY 2001 Estimate	FY 2002 Approved	Change FY 01-02 Amount	Percent
Agriculture	37	52	195	143	276.4%
(Agri. Research Service)	36	49	191	143	294.6%
(APHIS)	1	3	3	0	0.0%
Commerce (NIST)	10	4	10	6	151.8%
Department of Defense	190	235	353	118	50.1%
Department of Energy	60	68	194	126	184.7%
(NNSA)	55	63	109	46	72.1%
(Other Defense programs)	5	5	85	80	1635%
Environmental Protection Agency	0	0	70	70	- -
Health and Human Services	110	116	451	335	288.2%
(AHRQ)	5	0	0	0	- -
(CDC)	32	37	130	93	256.0%
(FDA)	0	0	20	20	- -
(NIH)	43	50	293	244	489.9%
(Office of Secretary)	30	30	8	-23	-75.0%
Justice	45	43	71	28	65.3%
(FBI)	15	7	7	0	0.0%
(Office of Justice Programs)	30	36	64	28	77.8%
Nat'l Aeronautics and Space Admin.	0	0	33	33	- -
State	7	5	6	1	24.0%
Transportation	51	55	101	47	85.2%
(FAA)	50	55	100	46	84.0%
(FTA)	1	0	1	1	700.0%
Treasury	2	1	1	0	0.0%
Total Terrorism R&D	511	579	1,484	905	156.5%

OMB data from OMB's Annual Report to Congress on Combating Terrorism, August 2001.

FY 2002 Approved figures are AAAS estimates of R&D in enacted FY 2002 appropriations bills, including emergency funds appropriated in Public Law 107-38 and allocated in appropriations bills, December 2001.

Figures include conduct of R&D and R&D facilities. Figures do not include non-R&D counterterrorism activities.

Table 8. R&D Funding by Congressional Appropriations Subcommittee
[budget authority in millions of dollars]

	FY 2001 Actual	FY 2002 Estimate	FY 2003 Budget	Change FY 02-03 Amount	Change FY 02-03 Percent
Defense 1	42,740	49,639	54,827	5,188	10%
VA, HUD, Independent Agencies	14,553	15,157	15,811	654	4%
Labor, DHHS, Education	21,201	24,292	27,734	3,442	14%
Energy & Water	7,027	7,522	7,626	104	1%
Interior	1,912	2,064	1,875	-188	-9%
Agriculture	1,981	2,187	1,992	-195	-9%
Commerce, Justice, State	1,118	1,194	1,214	20	2%
Transportation	718	778	736	-42	-5%
Foreign Operations	252	268	182	-86	-32%
Treasury, Postal, Gen. Gov't.	32	49	50	1	2%
Total R&D	91,534	103,150	112,047	8,897	9%

Source: AAAS, based on estimates for R&D from OMB and agency data.
Includes conduct of R&D and R&D facilities.
1 Some DOD R&D may be funded in Military Construction.

SUPPORTING TABLES FOR PCAST ISSUE 2

Non-federal R&D

Table 9. U.S. R&D Funding by Source, 1976-2000
[expenditures in billions of constant 2000 dollars]

	Total US	Federal Government		Private Industry		Other	
Year		funding amount	share of total	funding amount	share of total	funding amount	share of total
1976	99.7	51.3	51.5%	44.7	44.9%	3.6	3.7%
1977	103.1	52.6	51.0%	46.6	45.2%	3.9	3.7%
1978	108.1	54.2	50.2%	49.8	46.0%	4.1	3.8%
1979	113.5	55.9	49.2%	53.4	47.1%	4.2	3.7%
1980	118.6	56.3	47.5%	58.0	48.9%	4.3	3.7%
1981	123.9	57.8	46.7%	61.6	49.7%	4.5	3.6%
1982	130.5	60.1	46.1%	65.7	50.3%	4.7	3.6%
1983	139.8	64.5	46.2%	70.3	50.3%	5.0	3.6%
1984	153.2	69.7	45.5%	78.1	51.0%	5.4	3.5%
1985	166.5	76.5	46.0%	84.1	50.5%	5.9	3.5%
1986	170.8	77.7	45.5%	86.6	50.7%	6.6	3.9%
1987	174.0	80.7	46.4%	86.2	49.5%	7.1	4.1%
1988	178.5	80.2	44.9%	90.6	50.8%	7.7	4.3%
1989	182.2	77.7	42.6%	96.2	52.8%	8.3	4.6%
1990	187.9	76.2	40.6%	102.8	54.7%	8.9	4.7%
1991	191.9	72.5	37.8%	110.1	57.4%	9.3	4.8%
1992	192.5	70.9	36.8%	112.0	58.2%	9.6	5.0%
1993	188.4	68.8	36.5%	109.8	58.3%	9.8	5.2%
1994	188.4	67.7	35.9%	110.5	58.6%	10.3	5.4%
1995	200.1	68.6	34.3%	120.8	60.4%	10.7	5.3%
1996	211.0	67.8	32.1%	131.9	62.5%	11.3	5.3%
1997	222.7	67.9	30.5%	142.9	64.1%	11.9	5.4%
1998	235.0	69.2	29.5%	153.2	65.2%	12.6	5.4%
1999	249.1	69.1	27.7%	166.7	66.9%	13.3	5.3%
2000	264.6	69.6	26.3%	181.0	68.4%	14.0	5.3%

Other = R&D funding from nonprofit institutions, state and local governments, and universities and colleges with their own funds.

Source: AAAS, based on National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources: 2000 Data Update*, 2001. (Data for 2000 are preliminary). Excludes R&D facilities.

Table 10. U.S. R&D Funding by Source as Percentage of GDP

Year	Total U.S. Funded R&D	Total Federally Funded R&D	Total Industry-Funded R&D
1976	2.16%	1.11%	0.97%
1977	2.14%	1.09%	0.97%
1978	2.12%	1.07%	0.98%
1979	2.16%	1.06%	1.02%
1980	2.26%	1.07%	1.11%
1981	2.31%	1.08%	1.15%
1982	2.48%	1.14%	1.25%
1983	2.55%	1.18%	1.28%
1984	2.60%	1.18%	1.33%
1985	2.72%	1.25%	1.38%
1986	2.70%	1.23%	1.37%
1987	2.66%	1.23%	1.32%
1988	2.62%	1.18%	1.33%
1989	2.59%	1.10%	1.37%
1990	2.62%	1.06%	1.43%
1991	2.69%	1.02%	1.54%
1992	2.62%	0.96%	1.52%
1993	2.49%	0.91%	1.45%
1994	2.40%	0.86%	1.41%
1995	2.48%	0.85%	1.50%
1996	2.53%	0.81%	1.58%
1997	2.55%	0.78%	1.64%
1998	2.58%	0.76%	1.68%
1999	2.63%	0.73%	1.76%
2000	2.66%	0.70%	1.82%

Source: AAAS, based on based on National Science Foundation, Division of Science Resources Statistics, *National Patterns of R&D Resources: 2000 Data Update* (Data for 2000 are preliminary.) R&D funded by other sources (universities, nonprofits, etc.) included in Total U.S. Funded R&D. Includes defense and nondefense R&D. Excludes R&D facilities.

SUPPORTING TABLES FOR PCAST ISSUE 3

R&D Balance

Table 11. Federal Obligations for Total Research, by Broad Field of S&E: FY 1970–2002
[in millions of constant FY 2000 dollars]

Year	**Total, all fields**	Life sciences	Psychology	Physical sciences	Environmental sciences	Math & computer science	Engineering	Social sciences	Other sciences, n.e.c.
1970	**18,104.2**	5,318.9	397.4	3,495.6	1,793.7	350.7	5,686.5	784.1	277.2
1971	**18,303.6**	5,672.6	386.0	3,234.7	1,909.1	380.8	5,311.6	1,086.1	322.7
1972	**18,934.1**	6,310.4	397.0	3,482.4	1,937.2	412.0	4,951.2	1,047.4	396.5
1973	**18,240.0**	6,310.8	359.2	3,208.3	1,897.1	375.0	4,479.0	976.4	634.0
1974	**18,838.4**	6,910.1	407.0	3,099.7	1,941.2	348.6	4,770.4	891.4	470.1
1975	**18,605.8**	6,787.9	384.8	3,031.9	2,010.7	346.3	4,749.2	834.4	460.5
1976	**19,672.9**	6,841.5	371.8	3,250.4	1,986.3	407.4	5,341.2	1,013.3	461.0
1977	**20,447.0**	7,223.2	375.1	3,674.8	2,175.8	470.4	5,074.2	1,023.4	430.0
1978	**21,593.1**	7,703.2	397.1	3,698.9	2,302.9	486.1	5,442.1	1,100.2	462.6
1979	**21,902.3**	8,000.6	410.4	3,726.7	2,288.9	437.2	5,346.4	1,096.3	595.8
1980	**22,140.9**	8,003.7	379.9	3,819.4	2,407.3	460.0	5,403.1	1,000.0	667.4
1981	**21,254.4**	7,719.5	363.6	3,864.4	1,951.1	485.4	5,345.5	865.6	659.2
1982	**21,181.2**	7,718.8	355.2	4,067.0	1,867.8	569.5	5,508.3	627.7	466.8
1983	**22,208.6**	8,067.8	375.4	4,505.1	1,949.5	653.5	5,479.9	678.2	499.2
1984	**22,507.6**	8,468.7	400.8	4,461.3	1,917.2	661.6	5,445.7	655.6	496.6
1985	**23,466.8**	9,254.5	475.8	4,430.5	2,041.7	836.2	5,262.0	669.1	496.9
1986	**23,440.6**	9,182.2	474.4	4,359.5	2,104.7	874.1	5,310.9	590.2	544.5
1987	**24,800.2**	10,148.5	510.8	4,496.3	2,089.6	885.5	5,399.9	663.5	605.9
1988	**24,963.3**	10,339.3	521.8	4,440.2	2,151.0	860.5	5,295.7	650.2	704.7
1989	**26,766.6**	10,950.1	543.6	4,776.0	2,285.6	947.9	5,726.0	710.2	827.0
1990	**26,860.1**	10,968.7	557.3	4,731.3	2,700.7	1,044.3	5,250.4	782.6	824.5
1991	**28,660.1**	11,505.4	576.8	5,064.3	2,570.6	1,080.6	5,912.4	869.7	1,080.2
1992	**28,537.2**	11,548.0	347.4	5,172.7	2,572.4	1,352.0	5,799.3	803.7	941.9
1993	**30,602.6**	12,259.1	626.7	5,038.1	2,968.6	1,394.6	6,258.6	768.1	1,288.8
1994	**30,534.9**	12,570.2	610.9	4,738.2	3,161.6	1,449.9	6,103.8	721.2	1,179.0
1995	**31,004.7**	12,878.6	678.9	4,665.0	3,112.4	1,721.8	6,224.4	740.1	983.3
1996	**30,208.2**	12,896.1	561.2	4,193.5	3,227.9	1,680.0	6,072.6	699.7	877.3
1997	**30,790.9**	13,276.0	571.9	4,350.6	3,193.6	1,753.0	5,966.6	730.1	949.3
1998	**31,970.9**	14,017.4	611.0	4,352.5	3,165.8	1,899.1	6,095.3	833.4	996.4
1999	**34,218.7**	15,740.5	645.6	4,150.0	3,159.1	2,021.4	6,392.5	872.5	1,237.1
2000	**38,470.6**	17,964.7	1,626.7	4,788.0	3,328.8	2,205.6	6,346.4	1,050.3	1,160.2
2001*	**42,846.3**	20,641.3	1,828.6	5,046.3	3,577.9	2,402.8	6,930.5	1,188.7	1,230.2
2002*	**43,350.1**	21,235.9	1,984.8	4,920.4	3,485.3	2,503.7	6,724.8	1,215.6	1,279.6

n.e.c. = Not elsewhere classified

*FY 2001 and 2002 data are preliminary.

NOTE: Constant-dollar conversions based on OMB's GDP deflators from the *Budget of the U.S. Government FY 2003*

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development: Detailed Historical Tables: Fiscal Years 1951-2001.

Table 12. Changes in Federal Obligations, by Broad Field
[in constant FY 2000 dollars]

	1970-1975	1976-1980	1981-1985	1986-1990	1991-1995	1996-2000	1993-1999	1993-2000	1993-2001*	1993-2002*
Total, all fields	2.8%	12.5%	10.4%	14.6%	7.6%	27.4%	11.8%	25.7%	40.0%	41.7%
Life sciences	27.6%	17.0%	19.9%	19.5%	10.7%	39.3%	28.4%	46.5%	68.4%	73.2%
Psychology	-3.2%	2.2%	30.9%	17.5%	15.0%	189.9%	3.0%	159.6%	191.8%	216.7%
Physical sciences	-13.3%	17.5%	14.6%	8.5%	-8.6%	14.2%	-17.6%	-5.0%	0.2%	-2.3%
Environmental sciences	12.1%	21.2%	4.6%	28.3%	17.4%	3.1%	6.4%	12.1%	20.5%	17.4%
Math & computer science	-1.3%	12.9%	72.3%	19.5%	37.2%	31.3%	45.0%	58.2%	72.3%	79.5%
Engineering	-16.5%	1.2%	-1.6%	-1.1%	5.0%	4.5%	2.1%	1.4%	10.7%	7.5%
Social sciences	6.4%	-1.3%	-22.7%	32.6%	-17.5%	50.1%	13.6%	36.7%	54.8%	58.3%
Other sciences, n.e.c.	66.1%	44.8%	-24.6%	51.4%	-9.9%	32.2%	-4.0%	-10.0%	-4.6%	-0.7%

*FY 2001 and 2002 data are preliminary.

SOURCE: RAND

Table 13. Federal Obligations for Total Research, by Detailed Field of Science and Engineering: FY 1970-1980

[Millions of FY 2000 dollars]

Field of science & engineering	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Total, all fields	18,104.2	18,303.6	18,934.1	18,240.0	18,838.4	18,605.8	19,672.9	20,447.0	21,593.1	21,902.3	22,140.9
Life sciences, total	5,318.9	5,672.6	6,310.4	6,310.8	6,910.1	6,787.9	6,841.5	7,223.2	7,703.2	8,000.6	8,003.7
Biol & agricultural, total	3,197.7	3,368.5	3,685.0	3,670.7	4,015.2	4,014.9	3,965.4	4,268.9	4,549.4	4,824.0	4,787.2
Biol (excl environmental)	NA	NA	NA	NA	NA	NA	NA	NA	3,345.6	3,539.0	3,494.9
Environmental biology	NA	NA	NA	NA	NA	NA	NA	NA	415.5	450.2	438.6
Agricultural	NA	NA	NA	NA	NA	NA	NA	NA	788.3	834.8	853.8
Medical sciences, total	2,005.2	2,131.9	2,434.1	2,479.0	2,778.6	2,629.5	2,692.8	2,734.8	2,893.8	2,870.3	2,934.1
Life sciences, n.e.c.	116.0	172.3	191.3	161.0	116.3	143.5	183.2	219.6	260.0	306.3	282.3
Psychology, total	397.4	386.0	397.0	359.2	407.0	384.8	371.8	375.1	397.1	410.4	379.9
Biological aspects	119.5	112.0	125.9	105.9	150.5	103.5	113.1	138.4	120.1	118.0	114.3
Social aspects	197.5	193.2	173.1	155.9	158.5	157.8	141.8	130.9	147.0	173.9	181.0
Psychological sci, n.e.c.	80.4	80.8	98.0	97.4	98.0	123.5	116.9	105.9	130.1	118.5	84.6
Physical sciences, total	3,495.6	3,234.7	3,482.4	3,208.3	3,099.7	3,031.9	3,250.4	3,674.8	3,698.9	3,726.7	3819.4
Astronomy	504.1	453.2	465.5	402.2	415.0	465.4	421.1	473.8	480.1	591.3	545.4
Chemistry	840.5	734.3	842.4	857.8	855.3	789.5	848.0	890.3	910.3	922.3	867.8
Physics	2,048.7	1,889.2	1,957.6	1,775.3	1,698.1	1,644.9	1,831.3	2,080.4	2,118.3	2,126.3	2,257.6
Physical sciences, n.e.c.	102.3	158.0	216.8	173.0	131.3	132.2	150.0	230.3	190.2	86.8	148.6
Environmental sciences, total	1,793.7	1,909.1	1,937.2	1,897.1	1,941.2	2,010.7	1,986.3	2,175.8	2,302.9	2,288.9	2,407.3
Atmospheric sciences	859.9	928.4	823.7	805.8	879.5	835.6	747.0	764.6	717.5	725.0	781.8
Geological sciences	564.5	557.4	549.8	550.3	479.1	530.0	586.5	647.0	711.1	745.7	767.0
Oceanography	294.6	342.4	397.5	319.9	366.1	397.5	423.4	470.4	503.1	458.4	500.4
Environmental sci, n.e.c.	74.7	80.9	166.3	221.1	216.5	247.5	229.4	293.7	371.3	359.9	358.1
Math & computer sci, total	350.7	380.8	412.0	375.0	348.6	346.3	407.4	470.4	486.1	437.2	460.0
Mathematics	NA	NA	NA	NA	NA	NA	180.4	231.5	209.8	175.0	173.6
Computer sciences	NA	NA	NA	NA	NA	NA	190.0	214.6	241.1	220.9	245.5
Math & computer sci, n.e.c.	NA	NA	NA	NA	NA	NA	37.0	24.3	35.2	41.3	40.9
Engineering, total	5,686.5	5,311.6	4,951.2	4,479.0	4,770.4	4,749.2	5,341.2	5,074.2	5,442.1	5,346.4	5,403.1
Aeronautical	1,241.1	1,037.8	714.9	760.4	1,025.3	954.0	1,360.3	981.9	1,085.3	1,299.2	1,351.9
Astronautical	656.8	547.4	223.8	150.1	297.3	273.9	463.2	381.8	371.2	522.1	577.2
Chemical	404.3	376.9	263.0	235.2	187.5	231.9	227.9	251.7	335.9	237.6	183.9
Civil	262.6	274.2	420.8	347.0	316.1	347.2	273.4	281.8	320.1	259.9	303.1
Electrical	1,047.3	993.0	1,138.8	972.5	821.4	793.4	768.6	919.1	972.4	868.7	987.3
Mechanical	658.8	675.8	596.4	695.9	401.8	449.2	479.4	478.3	526.3	407.2	397.1
Metallurgy & materials	504.1	562.4	621.4	563.7	581.6	613.3	709.8	705.7	642.8	518.4	450.9
Engineering, n.e.c.	911.4	844.3	972.1	754.3	1,139.4	1,086.2	1,058.6	1,073.9	1,188.1	1,233.3	1,151.7
Social sciences, total	784.1	1,086.1	1,047.4	976.4	891.4	834.4	1,013.3	1,023.4	1,100.2	1,096.3	1,000.0
Anthropology	31.9	41.8	44.9	38.6	40.9	38.3	35.1	29.7	43.9	36.1	32.8
Economics	287.1	260.0	279.1	288.1	359.9	349.0	355.2	343.1	366.8	378.2	368.0
Political science	28.9	17.9	15.6	23.2	25.8	32.3	18.7	20.4	19.8	28.9	23.2
Sociology	139.6	376.2	407.4	333.6	196.1	151.8	138.5	125.3	135.6	134.1	136.4
Social sciences, n.e.c.	296.6	390.1	300.4	293.0	268.7	263.0	465.8	504.9	534.1	518.9	439.6
Other sciences, n.e.c.	277.2	322.7	396.5	634.0	470.1	460.5	461.0	430.0	462.6	595.8	667.4

NA = Not applicable (data not recorded at that level in that particular fiscal year)

n.e.c. = Not elsewhere classified

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 13. Federal Obligations for Total Research, by Detailed Field of Science and Engineering: FY 1981-1991 (continued)
[Millions of FY 2000 dollars]

Field of science & engineering	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all fields	21,254.4	21,181.2	22,208.6	22,507.6	23,466.8	23,440.6	24,800.2	24,963.3	26,766.6	26,860.1	28,660.1
Life sciences, total	7,719.5	7,718.8	8,067.8	8,468.7	9254.5	9182.2	10148.5	10339.3	10950.1	10968.7	11505.4
Biol & agricultural, total	4,719.5	4,573.5	4,774.7	4,996.2	5462.3	5484.8	6025.0	6121.5	6470.7	6432.8	6693.7
Biol (excl environmental)	3,474.8	3,382.1	3,592.2	3,851.4	4197.4	4252.0	4841.0	4928.0	5134.3	5148.6	5330.4
Environmental biology	383.4	298.5	301.7	375.7	378.6	375.1	400.3	402.9	474.1	425.2	549.7
Agricultural	861.1	893.0	880.6	769.3	886.3	857.7	783.7	790.7	862.3	858.9	813.5
Medical sciences, total	2,801.8	2,883.9	3,003.3	3,174.8	3445.1	3352.8	3683.7	3936.6	4153.8	4201.7	4137.6
Life sciences, n.e.c.	198.2	261.4	290.0	297.7	347.2	344.6	439.9	281.2	325.6	334.3	674.2
Psychology, total	363.6	355.2	375.4	400.8	475.8	474.4	510.8	521.8	543.6	557.3	576.8
Biological aspects	100.1	96.9	98.5	121.4	132.7	128.0	135.9	140.9	157.0	162.2	167.6
Social aspects	162.7	159.6	163.1	162.0	207.9	203.8	213.6	200.0	193.2	220.5	236.2
Psychological sci, n.e.c.	100.8	98.7	113.7	117.4	135.4	142.6	161.3	181.0	193.2	174.5	173.1
Physical sciences, total	3,864.4	4,067.0	4,505.1	4,461.3	4430.5	4359.5	4496.3	4440.2	4776.0	4731.3	5064.3
Astronomy	489.0	448.6	556.9	574.5	603.2	665.1	721.9	630.2	698.5	741.9	755.4
Chemistry	847.4	782.7	810.7	911.2	946.0	940.9	940.4	941.1	1008.8	946.2	990.6
Physics	2,341.8	2,619.6	2,889.7	2,759.4	2641.5	2565.2	2562.3	2644.0	2823.9	2801.1	2942.6
Physical sciences, n.e.c.	186.2	216.2	248.1	216.2	239.7	188.4	271.8	225.0	244.8	242.2	375.8
Environmental sciences, total	1,951.1	1,867.8	1,949.5	1,917.2	2041.7	2104.7	2089.6	2151.0	2285.6	2700.7	2570.6
Atmospheric sciences	649.8	692.6	717.8	652.3	706.9	740.5	764.3	786.8	757.9	960.7	959.8
Geological sciences	689.3	581.7	519.6	539.4	624.0	630.5	610.6	591.1	699.7	821.2	871.3
Oceanography	455.4	425.0	535.2	546.2	579.6	610.4	590.8	616.2	634.1	646.1	476.6
Environmental sci, n.e.c.	156.5	168.5	176.8	179.3	131.2	123.3	123.7	156.7	194.0	272.7	262.8
Math & computer sci, total	485.4	569.5	653.5	661.6	836.2	874.1	885.5	860.5	947.9	1044.3	1080.6
Mathematics	204.8	208.4	208.0	226.9	267.1	262.1	282.7	291.7	304.3	299.8	272.2
Computer sciences	211.5	278.0	334.4	322.3	407.7	429.5	411.7	391.8	470.0	698.3	699.4
Math & computer sci, n.e.c.	69.1	83.0	111.2	112.4	161.5	182.5	191.2	177.1	173.8	46.3	108.9
Engineering, total	5,345.5	5,508.3	5,479.9	5,445.7	5262.0	5310.9	5399.9	5295.7	5726.0	5250.4	5912.4
Aeronautical	1,234.9	1,205.6	1,278.6	1,292.9	1073.5	1101.7	1120.3	1073.2	1272.0	1151.7	1215.1
Astronautical	528.9	472.8	500.9	596.2	617.7	748.4	863.4	770.2	873.2	721.5	780.9
Chemical	256.9	154.7	225.9	217.1	369.9	349.1	298.3	345.5	183.3	300.5	363.9
Civil	276.9	328.4	293.7	304.7	315.1	288.2	282.6	287.6	296.2	394.7	364.7
Electrical	968.8	995.8	958.1	946.7	911.7	958.0	1087.0	978.6	1086.7	795.0	872.8
Mechanical	356.1	327.3	415.1	286.3	388.4	335.9	322.8	322.3	331.8	333.3	401.2
Metallurgy & materials	445.5	502.8	518.1	512.5	638.8	632.1	500.4	611.3	671.6	688.8	849.8
Engineering, n.e.c.	1,277.2	1,521.0	1,289.5	1,289.3	946.9	897.3	925.2	907.2	1011.2	865.0	1064.0
Social sciences, total	865.6	627.7	678.2	655.6	669.1	590.2	663.5	650.2	710.2	782.6	869.7
Anthropology	25.2	23.7	19.9	27.9	26.2	19.3	21.0	19.1	17.9	17.9	19.1
Economics	359.7	255.5	258.0	221.3	232.3	186.5	205.3	213.5	215.0	245.0	224.1
Political science	18.8	12.2	17.3	16.2	21.2	16.5	15.6	16.3	17.4	16.3	20.3
Sociology	113.1	84.6	105.6	105.5	96.7	95.2	102.3	109.5	121.3	144.3	220.0
Social sciences, n.e.c.	348.8	251.6	277.3	284.7	292.8	272.7	319.3	291.8	338.7	359.1	386.1
Other sciences, n.e.c.	659.2	466.8	499.2	496.6	496.9	544.5	605.9	704.7	827.0	824.5	1080.2

n.e.c. = Not elsewhere classified

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 13. Federal Obligations for Total Research, by Detailed Field of Science and Engineering: FY 1992-2002 (continued)

[Millions of FY 2000 dollars]

Field of science & engineering	1992	1993	1994	1995	1996	1997	1998	1999	2000	Preliminary	
										2001	2002
Total, all fields	28,537.2	30,602.6	30,534.9	31,004.7	30,208.2	30,790.9	31,970.9	34,218.7	38,470.6	42,846.3	43,350.1
Life sciences, total	11,548.0	12,259.1	12,570.2	12,878.6	12,896.1	13,276.0	14,017.4	15,740.5	17,964.7	20,641.3	21,235.9
Biol & agricultural, total	6,564.4	6,895.8	6,798.5	6,981.2	7,087.0	6,861.7	7,313.7	8,213.6	12,375.0	NA	NA
Biol (excl environmental)	5,167.9	5,451.1	5,286.6	5,370.6	5,676.0	5,578.5	5,900.1	6,611.1	10,740.0	NA	NA
Environmental biology	595.4	633.3	701.7	879.8	752.5	610.8	625.0	735.5	740.0	NA	NA
Agricultural	801.1	811.3	810.1	730.9	658.5	672.4	788.7	866.9	895.0	NA	NA
Medical sciences	4,555.9	5,012.4	5,416.2	5,421.7	5,316.3	5,801.3	6,199.6	6,941.4	4,463.8	NA	NA
Life sciences, n.e.c.	427.6	350.9	355.7	475.7	492.9	613.0	503.9	585.4	1,125.9	NA	NA
Psychology, total	347.4	626.7	610.9	678.9	561.2	571.9	611.0	645.6	1,626.7	1,828.6	1,984.8
Biological aspects	40.3	42.3	53.6	64.1	67.1	60.6	43.0	18.4	7.8	NA	NA
Social aspects	117.6	153.3	130.1	170.4	89.2	101.4	100.8	68.0	56.4	NA	NA
Psychological sci, n.e.c.	189.5	431.0	427.1	444.3	404.9	409.9	467.2	559.2	1,562.5	NA	NA
Physical sciences, total	5,172.7	5,038.1	4,738.2	4,665.0	4,193.5	4,350.6	4,352.5	4,150.0	4,788.0	5,046.3	4,920.4
Astronomy	861.2	781.0	832.8	833.6	779.3	812.3	757.0	773.5	880.3	NA	NA
Chemistry	1,044.3	959.6	974.0	941.6	941.8	886.9	846.8	831.7	1,225.6	NA	NA
Physics	3,004.2	3,002.6	2,721.5	2,672.8	2,128.6	2,168.0	2,204.1	2,267.7	2,405.4	NA	NA
Physical sciences, n.e.c.	263.0	295.0	209.8	217.2	343.8	483.4	544.6	277.0	276.7	NA	NA
Environmental sciences, total	2,572.4	2,968.6	3,161.6	3,112.4	3,227.9	3,193.6	3,165.8	3,159.1	3,328.8	3,577.9	3,485.3
Atmospheric sciences	894.1	1,119.9	1,219.8	1,238.3	1,160.6	1,220.8	1,214.2	1,200.8	1,104.3	NA	NA
Geological sciences	857.3	908.0	933.5	925.0	838.4	725.4	623.8	673.8	639.2	NA	NA
Oceanography	534.7	531.9	553.4	444.1	613.9	626.7	578.8	670.1	673.0	NA	NA
Environmental sci, n.e.c.	286.4	408.8	455.1	505.2	615.1	620.5	749.0	614.4	912.2	NA	NA
Math & computer sci, total	1,352.0	1,394.6	1,449.9	1,721.8	1,680.0	1,753.0	1,899.1	2,021.4	2,205.6	2,402.8	2,503.7
Mathematics	371.4	330.9	381.3	282.0	272.0	316.2	345.4	352.4	432.9	NA	NA
Computer sciences	899.3	940.1	924.8	1,105.6	1,197.0	1,326.1	1,446.1	1,547.4	1,659.6	NA	NA
Math & computer sci, n.e.c.	81.4	123.5	143.8	334.3	210.9	110.6	107.5	121.7	113.1	NA	NA
Engineering, total	5,799.3	6,258.6	6,103.8	6,224.4	6,072.6	5,966.6	6,095.3	6,392.5	6,346.4	6,930.5	6,724.8
Aeronautical	1,019.1	1,357.7	1,362.0	1,361.1	1,335.5	1,418.4	1,650.5	1,642.9	1,463.9	NA	NA
Astronautical	734.6	562.2	556.0	595.9	562.9	625.2	652.5	633.4	515.0	NA	NA
Chemical	346.7	279.4	265.3	268.3	229.9	246.4	196.5	207.4	196.5	NA	NA
Civil	384.8	286.8	309.6	370.1	320.9	289.0	252.4	335.3	239.2	NA	NA
Electrical	884.4	1,003.2	826.3	824.7	715.9	652.4	661.0	713.1	744.8	NA	NA
Mechanical	392.9	531.4	421.2	449.8	314.3	267.0	258.1	245.4	289.3	NA	NA
Metallurgy & materials	847.4	791.7	948.4	889.0	1,057.2	902.5	815.9	804.2	918.1	NA	NA
Engineering, n.e.c.	1,189.5	1,446.3	1,414.9	1,465.5	1,536.1	1,565.7	1,608.4	1,810.9	1,979.6	NA	NA
Social sciences, total	803.7	768.1	721.2	740.1	699.7	730.1	833.4	872.5	1,050.3	1,188.7	1,215.6
Anthropology	16.4	15.6	18.0	23.7	19.6	22.0	18.8	18.7	15.9	NA	NA
Economics	246.6	233.0	215.3	225.2	207.6	215.2	238.3	221.1	249.5	NA	NA
Political science	26.3	33.2	28.3	24.3	17.9	14.8	20.9	20.6	22.6	NA	NA
Sociology	94.0	87.3	75.9	52.1	44.0	27.2	104.2	85.5	90.6	NA	NA
Social sciences, n.e.c.	420.4	398.9	383.6	414.7	410.7	451.1	451.2	526.6	671.7	NA	NA
Other sciences, n.e.c.	941.9	1,288.8	1,179.0	983.3	877.3	949.3	996.4	1,237.1	1,160.2	1,230.2	1,279.6

NA = Not applicable (data collected not recorded at that level in that particular fiscal year)

n.e.c. = Not elsewhere classified

NOTE: NSF made changes to its field of science and engineering coding system, producing changes to some of the fiscal year 1996 field of science data (such as mechanical engineering and oceanography).

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 14. Recent Changes in Federal Obligations, by Detailed Field
[in constant FY 2000 dollars]

	All Performers				Universities and Colleges			
Field of science & engineering	1993-1999	1993-2000	1993-2001*	1993-2002*	1993-1999	1993-2000	1993-2001*	1993-2002*
Total, all fields	11.8%	25.7%	40.0%	41.7%	20.0%	43.5%	64.3%	67.6%
Life sciences, total	28.4%	46.5%	68.4%	73.2%	31.9%	49.5%	76.4%	80.4%
Biol & agricultural, total	19.1%	79.5%	NA	NA	34.6%	83.6%	NA	NA
Biol (excl environmental)	21.3%	97.0%	NA	NA	40.1%	97.2%	NA	NA
Environmental biology	16.1%	16.8%	NA	NA	8.8%	28.0%	NA	NA
Agricultural	6.9%	10.3%	NA	NA	21.9%	28.9%	NA	NA
Medical sciences, total	38.5%	-10.9%	NA	NA	20.6%	-17.5%	NA	NA
Life sciences, n.e.c.	66.9%	220.9%	NA	NA	117.2%	341.6%	NA	NA
Psychology, total	3.0%	159.6%	191.8%	216.7%	1.6%	174.6%	211.4%	241.0%
Biological aspects	-56.6%	-81.6%	NA	NA	-4.5%	-56.5%	NA	NA
Social aspects	-55.7%	-63.2%	NA	NA	-36.6%	-22.0%	NA	NA
Psychological sci, n.e.c.	29.8%	262.5%	NA	NA	4.4%	199.4%	NA	NA
Physical sciences, total	-17.6%	-5.0%	0.2%	-2.3%	1.2%	17.0%	25.4%	24.9%
Astronomy	-1.0%	12.7%	NA	NA	47.1%	67.0%	NA	NA
Chemistry	-13.3%	27.7%	NA	NA	-1.9%	57.2%	NA	NA
Physics	-24.5%	-19.9%	NA	NA	-7.3%	-16.8%	NA	NA
Physical sciences, n.e.c.	-6.1%	-6.2%	NA	NA	8.1%	22.5%	NA	NA
Environmental sciences, total	6.4%	12.1%	20.5%	17.4%	5.7%	35.5%	43.0%	43.2%
Atmospheric sciences	7.2%	-1.4%	NA	NA	13.9%	2.8%	NA	NA
Geological sciences	-25.8%	-29.6%	NA	NA	-31.5%	-36.5%	NA	NA
Oceanography	26.0%	26.5%	NA	NA	47.1%	40.2%	NA	NA
Environmental sci, n.e.c.	50.3%	123.1%	NA	NA	2.2%	224.8%	NA	NA
Math & computer sci, total	45.0%	58.2%	72.3%	79.5%	21.3%	42.1%	55.1%	62.6%
Mathematics	6.5%	30.8%	NA	NA	-13.4%	36.8%	NA	NA
Computer sciences	64.6%	76.5%	NA	NA	34.4%	47.8%	NA	NA
Math & computer sci, n.e.c.	-1.5%	-8.4%	NA	NA	38.9%	-29.1%	NA	NA
Engineering, total	2.1%	1.4%	10.7%	7.5%	5.7%	27.0%	40.2%	35.0%
Aeronautical	21.0%	7.8%	NA	NA	24.6%	17.8%	NA	NA
Astronautical	12.7%	-8.4%	NA	NA	79.6%	88.1%	NA	NA
Chemical	-25.8%	-29.7%	NA	NA	2.3%	7.8%	NA	NA
Civil	16.9%	-16.6%	NA	NA	6.5%	18.2%	NA	NA
Electrical	-28.9%	-25.8%	NA	NA	-11.9%	-18.4%	NA	NA
Mechanical	-53.8%	-45.6%	NA	NA	-40.4%	-45.8%	NA	NA
Metallurgy & materials	1.6%	16.0%	NA	NA	7.8%	22.9%	NA	NA
Engineering, n.e.c.	25.2%	36.9%	NA	NA	36.3%	122.9%	NA	NA
Social sciences, total	13.6%	36.7%	54.8%	58.3%	-3.9%	30.7%	46.7%	46.3%
Anthropology	19.8%	2.0%	NA	NA	42.0%	46.8%	NA	NA
Economics	-5.1%	7.1%	NA	NA	-20.3%	-1.4%	NA	NA
Political science	-38.0%	-32.0%	NA	NA	6.3%	8.3%	NA	NA
Sociology	-2.0%	3.8%	NA	NA	-61.9%	-49.1%	NA	NA
Social sciences, n.e.c.	32.0%	68.4%	NA	NA	19.1%	72.0%	NA	NA
Other sciences, n.e.c.	-4.0%	-10.0%	-4.6%	-0.7%	-10.1%	2.1%	12.2%	18.1%

NA = Not Applicable (data on detailed fields of S&E were not collected for these fiscal years)

*Numbers for FY 2001 and FY 2002 are preliminary

SOURCE: RAND

Table 15. Federal Obligations to Universities and Colleges for Research, by Detailed Field of Science & Engineering: FY 1973-1980
[Millions of FY 2000 dollars]

Field of science and engineering	1973	1974	1975	1976	1977	1978	1979	1980
Total, all fields	5,200.7	5,665.0	5,451.8	5,561.8	5,891.8	6,229.9	6,480.2	6,612.5
Life sciences, total	2,848.9	3,364.3	3,184.4	3,220.3	3,362.0	3,608.1	3,734.0	3,789.0
Biol & agricultural, total	1,606.2	1,953.2	1,860.8	1,877.9	1,949.8	2,122.7	2,278.7	2,285.9
Biol (excl environmental)	NA	NA	NA	NA	NA	1,823.2	1,968.3	1,979.7
Environmental biology	NA	NA	NA	NA	NA	64.7	82.0	75.3
Agricultural	NA	NA	NA	NA	NA	234.8	228.4	230.8
Medical sciences, total	1,139.2	1,319.8	1,235.6	1,237.3	1,293.1	1,351.6	1,294.3	1,354.9
Life sciences, n.e.c.	103.5	91.3	88.0	105.0	119.1	133.8	161.0	148.2
Psychology, total	152.6	173.7	151.4	150.9	142.3	152.2	186.7	170.6
Biological aspects	59.6	72.0	58.7	59.7	55.3	54.7	57.5	60.6
Social aspects	66.3	67.8	58.8	56.6	50.0	57.1	62.4	64.2
Psychological sci, n.e.c.	26.7	33.9	33.9	34.7	37.0	40.4	66.8	45.8
Physical sciences, total	765.4	741.1	739.6	718.1	783.1	824.0	837.4	880.1
Astronomy	98.5	92.8	78.5	73.6	83.1	84.1	84.5	87.4
Chemistry	230.8	230.9	248.1	243.3	278.1	277.6	291.4	304.5
Physics	398.6	399.6	397.9	386.3	401.1	446.6	446.4	469.8
Physical sciences, n.e.c.	37.4	17.7	15.1	14.8	20.9	15.7	15.1	18.4
Environmental sci, total	391.2	398.4	403.8	435.4	492.7	509.2	572.8	567.1
Atmospheric sciences	120.0	98.4	106.5	110.2	121.7	136.2	147.9	165.5
Geological sciences	62.1	105.1	110.4	133.2	133.5	134.3	163.0	159.0
Oceanography	143.3	171.5	168.2	164.0	198.1	207.4	226.2	200.0
Environmental sci, n.e.c.	65.8	23.5	18.6	28.0	39.5	31.3	35.7	42.7
Math & computer sci, total	161.3	161.2	159.0	148.7	175.0	178.7	182.0	180.6
Mathematics	NA	NA	NA	77.7	91.9	89.8	85.6	93.6
Computer sciences	NA	NA	NA	67.6	81.5	81.0	89.0	78.9
Math & computer sciences, n.e.c.	NA	NA	NA	3.5	1.6	7.8	7.4	8.2
Engineering, total	406.0	430.8	462.5	444.9	529.7	541.4	560.5	618.0
Aeronautical	34.4	44.2	42.5	43.2	47.9	52.9	55.4	72.1
Astronautical	12.4	9.7	8.0	9.0	7.0	6.8	4.7	14.0
Chemical	28.9	28.0	43.2	41.5	41.1	55.1	40.0	38.7
Civil	23.2	18.8	13.6	13.9	17.5	18.6	35.3	41.3
Electrical	86.3	83.4	77.3	92.5	123.8	119.5	111.3	147.5
Mechanical	58.8	45.0	39.8	43.2	52.0	51.5	54.9	62.9
Metallurgy & materials	85.6	98.6	104.7	102.9	112.7	110.5	108.8	109.4
Engineering, n.e.c.	76.3	103.1	133.4	98.8	127.7	126.5	150.1	132.2
Social sciences, total	302.7	276.1	252.4	306.9	328.1	328.3	287.3	263.0
Anthropology	15.7	20.2	17.6	13.6	11.8	15.7	16.3	12.2
Economics	82.3	91.8	92.7	84.9	90.7	95.6	94.8	96.6
Political science	5.5	7.3	6.8	5.5	6.7	8.1	10.7	8.2
Sociology	75.8	57.2	35.5	43.9	45.5	47.4	50.2	51.6
Social sciences, n.e.c.	123.4	99.6	99.9	159.0	173.3	161.4	115.3	94.4
Other sciences, n.e.c.	172.7	119.2	98.6	136.6	78.9	88.0	119.6	144.1

NA = Not applicable (data were not recorded at that level of detail for that particular fiscal year)

n.e.c. = Not elsewhere classified

NOTE: This table shows obligations from the Departments of Agriculture, Defense, Energy, and Health and Human Services; the National Aeronautics and Space Administration; and the National Science Foundation; they represent approximately 97 percent of total Federal research obligations to universities and colleges in fiscal years 1997, 1998, and 1999.

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 15. Federal Obligations to Universities and Colleges for Research, by Detailed Field of Science & Engineering: FY 1981-1991 (continued)
[Millions of FY 2000 dollars]

Field of science and engineering	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all fields	6,451.2	6,173.9	6,625.5	7,178.6	7,946.9	7,979.2	8,825.2	9,055.9	9,632.0	9,673.3	10,203.5
Life sciences, total	3,684.6	3,586.5	3,832.9	4,207.7	4,711.8	4,619.1	5,286.2	5,393.5	5,666.2	5,629.5	5,939.6
Biol & agricultural, total	2,252.3	2,175.3	2,326.0	2,534.1	2,825.9	2,786.7	3,208.6	3,237.9	3,387.4	3,315.3	3,476.5
Biol (excl environmental)	1,942.7	1,869.6	2,007.5	2,224.0	2,487.5	2,488.8	2,913.1	2,929.1	3,009.0	2,989.9	3,121.6
Environmental biology	66.7	66.6	67.6	144.1	143.7	133.8	134.0	132.4	182.5	158.9	178.5
Agricultural	242.9	239.2	250.8	165.9	194.8	164.1	161.6	176.4	196.0	166.5	176.4
Medical sciences, total	1,312.4	1,291.2	1,366.2	1,521.4	1,692.6	1,663.4	1,882.6	2,027.8	2,121.5	2,147.3	2,307.4
Life sciences, n.e.c.	119.9	119.9	140.8	152.2	193.2	168.9	195.0	127.8	157.2	166.8	155.7
Psychology, total	161.4	135.8	154.3	169.5	201.4	210.8	258.0	262.9	281.1	295.0	306.3
Biological aspects	51.6	42.2	45.1	55.4	65.4	67.3	76.8	87.3	100.8	97.8	102.9
Social aspects	55.9	43.8	49.5	49.3	58.0	59.4	75.0	57.1	66.8	87.8	95.0
Psychological sci, n.e.c.	53.9	49.8	59.7	64.7	78.0	84.0	106.2	118.4	113.5	109.4	108.4
Physical sciences, total	914.0	909.5	929.4	1048.5	1095.6	1068.0	1137.0	1146.9	1198.3	1244.1	1280.3
Astronomy	83.3	85.5	80.9	103.3	95.9	96.9	99.1	100.5	101.1	102.1	124.8
Chemistry	336.7	308.4	320.5	364.1	391.9	377.4	388.6	394.5	383.7	394.3	406.0
Physics	477.7	497.7	512.3	563.7	585.7	574.9	558.2	568.5	626.1	678.6	706.6
Physical sciences, n.e.c.	16.2	17.9	15.6	17.3	22.1	18.8	91.0	83.5	87.4	69.2	42.9
Environmental sci, total	487.9	446.8	493.8	480.0	525.3	519.5	553.4	546.2	593.6	607.1	668.0
Atmospheric sciences	143.9	129.7	126.3	144.8	149.6	158.3	158.6	151.7	157.8	161.4	175.9
Geological sciences	124.3	112.3	108.6	117.0	143.4	152.5	154.8	145.8	174.6	171.8	211.2
Oceanography	190.5	182.8	234.6	197.4	218.2	199.7	221.8	212.3	228.1	226.1	162.1
Environmental sci, n.e.c.	29.2	22.1	24.3	20.8	14.1	9.0	18.1	36.5	33.1	47.9	118.8
Math & computer sci, total	211.3	227.1	268.6	272.8	366.3	389.1	398.9	408.8	444.5	515.4	476.8
Mathematics	103.5	104.6	112.6	117.8	141.1	149.4	154.2	157.7	148.5	160.5	145.8
Computer sciences	87.3	109.2	125.9	111.5	148.9	158.3	153.5	157.0	204.7	350.2	301.0
Math & computer sciences, n.e.c.	20.4	13.4	30.1	43.5	76.3	81.4	91.2	94.2	91.3	4.7	30.0
Engineering, total	635.8	588.0	636.8	712.5	729.1	865.0	829.1	900.9	965.7	885.4	991.1
Aeronautical	68.4	62.6	64.7	67.7	61.1	85.4	92.5	80.3	92.5	104.4	69.7
Astronautical	15.2	15.6	24.0	15.2	16.5	18.7	19.5	23.9	25.5	25.1	26.2
Chemical	38.1	31.6	36.7	77.0	66.4	72.6	75.5	75.9	54.0	72.7	90.3
Civil	43.4	44.1	47.1	58.7	59.1	51.9	56.8	54.5	59.7	53.3	57.6
Electrical	149.8	144.1	142.8	180.6	172.2	196.8	198.0	186.2	195.3	171.6	170.7
Mechanical	63.2	65.9	77.8	83.1	96.3	117.6	105.4	99.0	112.8	96.3	117.7
Metallurgy & materials	121.0	122.5	133.9	131.7	155.9	189.3	149.0	234.4	250.2	205.6	255.6
Engineering, n.e.c.	136.8	101.6	109.6	98.5	101.8	132.8	132.4	146.9	175.7	156.4	203.2
Social sciences, total	237.3	184.6	195.5	167.0	177.9	157.9	178.6	184.5	200.1	217.7	255.5
Anthropology	10.1	9.5	8.9	10.2	10.2	10.8	11.6	10.9	10.4	10.1	10.4
Economics	85.2	85.6	91.0	49.3	53.2	48.4	54.3	55.6	58.8	61.1	60.9
Political science	7.0	4.4	4.9	6.5	7.5	5.6	5.1	6.0	7.0	6.8	7.2
Sociology	43.4	35.9	39.4	43.9	43.9	39.5	46.5	45.3	56.0	71.5	110.8
Social sciences, n.e.c.	91.7	49.2	51.3	57.1	63.2	53.6	61.0	66.7	68.1	68.2	66.3
Other sciences, n.e.c.	119.0	95.5	114.4	120.6	139.5	149.9	184.0	212.0	282.6	279.1	286.0

n.e.c. = Not elsewhere classified

NOTE: This table shows obligations from the Departments of Agriculture, Defense, Energy, and Health and Human Services; the National Aeronautics and Space Administration; and the National Science Foundation; they represent approximately 97 percent of total Federal research obligations to universities and colleges in fiscal years 1997, 1998, and 1999.

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 15. Federal Obligations to Universities and Colleges for Research, by Detailed Field of Science & Engineering: FY 1992-2002 (continued)

[Millions of FY 2000 dollars]

Field of science and engineering	1992	1993	1994	1995	1996	1997	1998	1999	2000	Preliminary	
										2001	2002
Total, all fields	10,074.2	10,861.8	11,048.1	10,857.1	11,056.5	11,303.4	11,696.4	13,039.5	15,588.8	17,845.3	18,202.4
Life sciences, total	5,839.1	6,259.8	6,398.2	6,152.5	6,433.5	6,884.8	7,242.9	8,257.9	9,357.2	11,039.3	11,290.9
Biol & agricultural, total	3,383.5	3,476.9	3,502.7	3,270.4	3,464.0	4,005.7	4,180.8	4,678.2	6,381.8	NA	NA
Biol (excl environmental)	3,003.4	3,124.5	3,136.4	2,918.1	3,157.1	3,670.5	3,865.9	4,376.7	6,162.9	NA	NA
Environmental biology	188.9	182.6	185.9	181.8	158.3	153.7	163.6	198.7	233.8	NA	NA
Agricultural	191.3	169.8	180.4	170.5	148.6	181.5	177.8	206.9	219.0	NA	NA
Medical sciences, total	2,358.2	2,659.0	2,793.6	2,692.1	2,761.4	2,660.5	2,806.4	3,206.4	2,194.4	NA	NA
Life sciences, n.e.c.	97.4	123.9	101.9	189.9	208.1	218.6	229.2	269.2	547.2	NA	NA
Psychology, total	150.3	327.2	350.7	307.0	275.2	297.2	307.4	332.3	898.3	1,018.7	1,115.7
Biological aspects	13.0	15.2	11.2	12.6	24.3	26.3	23.9	14.5	6.6	NA	NA
Social aspects	25.7	19.1	19.5	23.6	10.8	14.8	12.3	12.1	14.9	NA	NA
Psychological sci, n.e.c.	111.6	292.9	320.0	270.8	240.1	256.0	271.2	305.6	876.8	NA	NA
Physical sciences, total	1,340.7	1,334.5	1,301.6	1,301.9	1,204.4	1,220.4	1,245.0	1,350.0	1,561.2	1,673.4	1,666.5
Astronomy	229.6	136.7	147.7	182.0	205.8	176.2	179.3	201.1	228.3	NA	NA
Chemistry	410.0	396.0	419.6	395.8	389.1	357.4	342.7	388.6	622.5	NA	NA
Physics	668.3	691.9	669.3	643.1	546.9	547.4	596.7	641.6	575.7	NA	NA
Physical sciences, n.e.c.	32.8	109.9	65.0	80.9	62.5	139.3	126.3	118.8	134.6	NA	NA
Environmental sci, total	681.3	671.9	709.8	670.6	702.1	704.7	675.0	710.5	910.4	960.9	961.9
Atmospheric sciences	193.4	181.6	193.9	227.8	169.0	215.8	171.2	206.8	186.7	NA	NA
Geological sciences	199.1	214.5	228.9	186.7	146.1	130.2	177.2	146.9	136.3	NA	NA
Oceanography	174.0	167.0	164.8	121.1	224.3	225.9	203.9	245.6	234.0	NA	NA
Environmental sci, n.e.c.	114.8	108.8	122.2	135.1	162.8	132.9	122.6	111.2	353.3	NA	NA
Math & computer sci, total	556.6	557.8	601.7	583.5	695.4	599.3	645.3	676.7	792.9	865.4	906.9
Mathematics	175.3	154.6	157.1	145.2	145.3	123.9	137.0	134.0	211.5	NA	NA
Computer sciences	372.7	384.5	423.7	410.2	521.9	450.2	486.4	516.7	568.1	NA	NA
Math & computer sciences, n.e.c.	8.6	18.7	20.8	28.1	28.2	25.2	21.9	26.0	13.3	NA	NA
Engineering, total	974.2	1,010.6	1,063.4	1,189.4	1,154.1	1,036.0	1,027.4	1,067.7	1,283.4	1,417.2	1,364.6
Aeronautical	66.3	59.3	70.4	57.4	50.8	51.7	64.2	73.9	69.9	NA	NA
Astronautical	29.2	23.3	23.1	21.5	19.1	18.4	9.1	41.8	43.8	NA	NA
Chemical	81.3	74.4	67.3	77.0	64.8	65.7	75.8	76.1	80.2	NA	NA
Civil	46.4	42.9	41.6	56.4	48.0	47.3	49.0	45.7	50.8	NA	NA
Electrical	173.1	222.7	211.7	189.4	175.1	153.5	183.3	196.2	181.8	NA	NA
Mechanical	115.5	133.5	140.1	146.5	96.8	79.9	79.0	79.6	72.3	NA	NA
Metallurgy & materials	213.7	228.2	303.9	346.7	324.7	273.9	255.0	246.1	280.5	NA	NA
Engineering, n.e.c.	248.7	226.2	205.4	294.5	374.6	345.6	312.0	308.2	504.1	NA	NA
Social sciences, total	203.5	245.8	223.3	223.0	197.4	207.0	195.9	236.2	321.4	360.8	359.6
Anthropology	9.3	7.9	7.4	12.6	10.5	11.3	11.1	11.3	11.6	NA	NA
Economics	71.2	67.0	61.0	65.2	59.4	61.5	50.1	53.4	66.0	NA	NA
Political science	5.3	5.1	5.5	8.0	5.5	5.7	5.2	5.4	5.5	NA	NA
Sociology	50.3	38.8	30.8	17.8	12.9	15.2	14.3	14.8	19.7	NA	NA
Social sciences, n.e.c.	67.4	127.0	118.6	119.4	109.0	113.3	115.2	151.3	218.5	NA	NA
Other sciences, n.e.c.	328.5	454.3	399.3	429.3	394.4	354.0	357.4	408.3	464.1	509.8	536.4

NA = Not applicable (data were not recorded at that level of detail for that particular fiscal year)

n.e.c. = Not elsewhere classified

NOTE: This table shows obligations from the Departments of Agriculture, Defense, Energy, and Health and Human Services; the National Aeronautics and Space Administration; and the National Science Foundation; they represent approximately 97 percent of total Federal research obligations to universities and colleges in fiscal years 1997, 1998, and 1999.

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development Detailed Historical Tables: Fiscal Years 1951-2001.

Table 16. Total Federal Obligations for Research, by Agency: FY 1970-2002
[Millions of FY 2000 dollars]

Year	**Total**	USDA	DOC	DOD	DOE[1]	DHHS[2]	*NIH[3]*	DOI	EPA	NASA	NSF	All Other
1970	18,104	1,005	348	4,913	1,600	3,723	*2,883*	445	196	3,806	1,015	1,054
1971	18,304	1,044	406	4,678	1,533	4,177	*3,264*	489	192	3,296	1,137	1,352
1972	18,934	1,151	489	5,135	1,424	4,764	*3,752*	503	174	2,610	1,458	1,226
1973	18,240	1,157	425	4,693	1,388	4,645	*3,700*	523	243	2,595	1,516	1,054
1974	18,838	1,114	394	4,376	1,418	5,585	*4,544*	438	294	2,580	1,587	1,054
1975	18,606	1,111	399	3,956	1,641	5,294	*4,435*	647	392	2,585	1,576	1,004
1976	19,673	1,142	402	3,944	1,927	5,467	*4,564*	670	401	3,157	1,538	1,024
1977	20,447	1,258	423	4,121	2,140	5,702	*4,728*	615	493	2,896	1,653	1,146
1978	21,593	1,336	433	4,100	2,478	6,050	*5,018*	637	568	3,024	1,671	1,297
1979	21,902	1,314	456	4,187	2,353	6,270	*5,260*	706	538	3,017	1,663	1,398
1980	22,141	1,255	486	4,318	2,439	6,363	*5,322*	677	468	3,073	1,668	1,395
1981	21,254	1,290	434	4,526	2,460	6,078	*5,131*	644	380	2,449	1,663	1,331
1982	21,181	1,247	449	4,803	2,759	5,865	*5,082*	572	396	2,289	1,583	1,220
1983	22,209	1,274	444	5,021	3,056	6,265	*5,419*	557	272	2,407	1,655	1,258
1984	22,508	1,255	446	4,581	3,043	6,711	*5,876*	571	258	2,568	1,807	1,268
1985	23,467	1,325	472	4,608	3,114	7,314	*6,441*	537	312	2,594	1,957	1,233
1986	23,441	1,273	482	4,584	2,898	7,372	*6,516*	523	309	2,939	1,922	1,138
1987	24,800	1,270	468	4,628	2,900	8,325	*7,347*	528	383	3,137	2,033	1,129
1988	24,963	1,319	458	4,336	2,992	8,696	*7,604*	525	359	3,121	2,052	1,106
1989	26,767	1,292	452	4,713	3,134	9,137	*7,814*	570	352	3,711	2,153	1,252
1990	26,860	1,318	468	4,384	3,193	9,276	*7,871*	590	392	3,802	2,099	1,337
1991	28,660	1,406	538	4,446	3,914	9,760	*8,111*	662	422	4,031	2,135	1,347
1992	28,537	1,469	694	4,746	3,976	9,258	*8,621*	665	471	3,763	2,177	1,316
1993	30,603	1,425	662	5,444	3,915	10,462	*9,831*	660	411	4,039	2,142	1,443
1994	30,535	1,473	800	4,724	3,657	10,846	*10,114*	724	448	4,278	2,273	1,312
1995	31,005	1,416	973	4,578	3,773	10,987	*10,177*	581	438	4,412	2,344	1,504
1996	30,208	1,304	909	4,271	3,594	11,273	*10,558*	579	407	4,145	2,339	1,386
1997	30,791	1,353	847	3,995	3,741	11,773	*11,030*	579	429	4,388	2,358	1,328
1998	31,971	1,379	834	4,105	3,916	12,426	*11,672*	520	493	4,563	2,367	1,367
1999	34,219	1,519	865	4,228	4,001	13,997	*13,141*	623	466	4,448	2,558	1,546
2000	38,471	1,611	896	4,920	4,101	17,913	*16,918*	548	411	3,964	2,726	1,380
2001*	42,846	1,791	955	5,594	4,479	20,234	*19,033*	576	463	4,312	2,947	1,461
2002*	43,350	1,583	976	4,801	4,308	22,127	*21,024*	509	423	4,228	2,886	1,444

*FY 2001 and 2002 data are preliminary.

KEY: USDA = Department of Agriculture; DOC = Department of Commerce; DOD = Department of Defense; DOE[1] = Department of Energy (Atomic Energy Commission 1970-1975; Energy Research and Development Administration 1975-1976); DHHS[2] = Department of Health and Human Services (Department of Health, Education, and Welfare before 1979); NIH[3] = National Institutes of Health (part of DHHS); DOI = Department of the Interior; EPA = Environmental Protection Agency; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation.

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Federal Funds for Research and Development: Fiscal Years 2000, 2001, and 2002; and Federal Funds for Research and Development, Fiscal Years 1970-2001, Federal Obligations for Research by Agency and Detailed Field of Science and Engineering.

SUPPORTING TABLES FOR PCAST ISSUE 4

Education, Workforce and Research Outputs

Table 17. Full-time Graduate Students in Science, Engineering, and Health Fields, by Detailed Field: 1993-2000

Field	1993	1994	1995	1996	1997	1998	1999	2000
Total, all surveyed fields	329,701	332,149	329,356	328,628	327,385	327,522	334,421	342,121
Total, science and engineering fields	293,902	292,975	287,164	284,033	280,664	278,941	283,911	292,026
Sciences, total	220,094	221,405	219,382	218,174	214,976	213,506	215,888	219,421
Physical sciences, total	30,616	30,049	28,879	27,931	26,882	26,391	26,635	26,552
Astronomy	848	953	871	854	768	787	808	823
Chemistry	17,204	17,104	16,736	16,479	15,992	15,777	15,959	15,707
Physics	12,397	11,766	11,052	10,400	9,923	9,661	9,660	9,811
Other physical sciences	167	226	220	198	199	166	208	211
Earth, atmospheric and ocean sciences, total	11,346	11,446	11,259	10,795	10,510	10,444	10,484	10,559
Atmospheric sciences	980	993	959	980	966	856	793	844
Geosciences	5,962	5,933	5,786	5,576	5,413	5,212	5,238	5,259
Oceanography	2,180	2,340	2,235	2,075	1,973	2,048	2,123	2,164
Other earth, atmospheric, and ocean sciences	2,224	2,180	2,279	2,164	2,158	2,328	2,330	2,292
Mathematical sciences	14,530	14,226	13,410	12,966	12,144	11,751	11,796	11,732
Computer sciences	17,401	16,701	16,510	17,195	18,335	19,972	22,708	26,644
Agricultural sciences	9,446	9,479	9,605	9,297	9,096	8,986	9,156	9,113
Biological sciences, total	46,367	47,961	48,285	47,684	46,923	46,992	47,107	47,026
Psychology, total	34,782	35,288	35,222	35,412	35,551	35,148	34,705	35,066
Social sciences, total	55,606	56,255	56,212	56,894	55,535	53,822	53,297	52,729
Agricultural economics	1,963	1,936	1,977	1,784	1,718	1,670	1,685	1,780
Anthropology	5,429	5,837	5,792	6,003	5,799	5,734	5,814	5,624
Economics	10,107	9,945	9,743	9,548	8,813	8,564	8,390	8,652
Geography	3,026	3,119	2,962	2,959	2,967	2,908	2,786	2,663
Linguistics	2,538	2,518	2,486	2,530	2,420	2,286	2,182	2,104
Political science	18,372	17,918	17,630	17,669	17,071	16,316	16,178	16,099
Sociology	6,625	6,720	6,692	6,610	6,717	6,460	6,278	6,137
Sociology/anthropology	639	693	663	620	666	615	518	524
Other social sciences	6,907	7,569	8,267	9,171	9,364	9,269	9,466	9,146
Engineering, total	73,808	71,570	67,782	65,859	65,688	65,435	68,023	72,605
Aerospace engineering	3,262	3,000	2,693	2,576	2,529	2,565	2,645	2,759
Agricultural engineering	835	879	859	799	748	756	767	706
Biomedical engineering	2,269	2,292	2,315	2,316	2,462	2,513	2,742	2,874
Chemical engineering	6,079	6,136	5,985	5,939	5,821	5,630	5,593	5,865
Civil engineering	12,458	12,641	12,248	11,791	11,406	11,154	11,237	11,765
Electrical engineering	20,343	19,385	18,167	17,967	18,854	19,470	20,219	22,821
Engineering science	1,397	1,347	1,243	1,057	1,018	1,114	1,035	1,098
Industrial/manufacturing engineering	5,950	5,960	5,389	5,166	5,116	4,894	5,500	6,089
Mechanical engineering	12,395	11,875	11,128	10,690	10,432	10,073	10,331	10,929
Metallurgical/materials engineering	4,294	4,143	3,912	3,724	3,694	3,736	3,563	3,601
Nuclear engineering	1,070	997	883	771	708	662	641	660
Other engineering	3,456	2,915	2,960	3,063	2,900	2,868	3,750	3,438
Total, health fields	35,799	39,174	42,192	44,595	46,721	48,581	50,510	50,095
Medical fields, total	7,559	7,806	8,273	8,210	8,567	9,173	9,681	9,141
Other health fields, total	28,240	31,368	33,919	36,385	38,154	39,408	40,829	40,954

SOURCE: RAND, based on National Science Foundation, Graduate Students and Postdoctorates in Science and Engineering, Fall 2000.

Table 18. Full-time Graduate Students in Science, Engineering, and Health Fields, by Field and Primary Source of Support: 1993-2000

Field and primary source of support	1993	1994	1995	1996	1997	1998	1999	2000	Change in Number 1993-2000	Change in Percent 1993-2000
All surveyed fields, total										
Total, all sources	329,701	332,149	329,356	328,628	327,385	327,522	334,421	342,121	12,420	3.8%
Federal, total	67,688	68,566	67,310	65,251	64,529	63,759	65,809	67,625	-63	-0.1%
Science and engineering, total										
Total, all sources	293,902	292,975	287,164	284,033	280,664	278,941	283,911	292,026	-1,876	-0.6%
Federal, total	60,375	60,778	59,398	57,838	56,798	55,810	57,351	59,254	-1,121	-1.9%
Sciences, total										
Total, all sources	220,094	221,405	219,382	218,174	214,976	213,506	215,888	219,421	-673	-0.3%
Federal, total	43,474	43,905	43,025	41,992	40,909	40,289	41,446	42,566	-908	-2.1%
Physical sciences										
Total, all sources	30,616	30,049	28,879	27,931	26,882	26,391	26,635	26,552	-4,064	-13.3%
Federal, total	11,140	11,032	10,339	9,875	9,450	9,123	9,239	9,233	-1,907	-17.1%
Earth, atmospheric, & ocean sciences										
Total, all sources	11,346	11,446	11,259	10,795	10,510	10,444	10,484	10,559	-787	-6.9%
Federal, total	3,652	3,630	3,472	3,273	3,119	2,959	2,965	2,993	-659	-18.0%
Mathematical sciences										
Total, all sources	14,530	14,226	13,410	12,966	12,144	11,751	11,796	11,732	-2,798	-19.3%
Federal, total	1,474	1,397	1,287	1,237	1,152	1,044	1,103	1,368	-106	-7.2%
Computer sciences										
Total, all sources	17,401	16,701	16,510	17,195	18,335	19,972	22,708	26,644	9,243	53.1%
Federal, total	2,920	3,067	3,176	3,106	3,173	3,309	3,361	3,674	754	25.8%
Agricultural sciences										
Total, all sources	9,446	9,479	9,605	9,297	9,096	8,986	9,156	9,113	-333	-3.5%
Federal, total	1,952	1,903	2,048	1,959	1,761	1,665	1,891	1,895	-57	-2.9%
Biological sciences										
Total, all sources	46,367	47,961	48,285	47,684	46,923	46,992	47,107	47,026	659	1.4%
Federal, total	16,192	16,713	16,637	16,543	16,357	16,233	16,495	16,712	520	3.2%
Psychology										
Total, all sources	34,782	35,288	35,222	35,412	35,551	35,148	34,705	35,066	284	0.8%
Federal, total	2,653	2,634	2,543	2,752	2,720	2,927	3,255	3,308	655	24.7%
Social sciences										
Total, all sources	55,606	56,255	56,212	56,894	55,535	53,822	53,297	52,729	-2,877	-5.2%
Federal, total	3,491	3,529	3,523	3,247	3,177	3,029	3,137	3,383	-108	-3.1%

Table 18. Full-time Graduate Students in Science, Engineering, and Health Fields, by Field and Primary Source of Support: 1993-2000 (continued) **Page 2 of 2**

Field and primary source of support	1993	1994	1995	1996	1997	1998	1999	2000	Change in Number 1993-2000	Change in Percent 1993-2000
Engineering, total										
Total, all sources	73,808	71,570	67,782	65,859	65,688	65,435	68,023	72,605	-1,203	-1.6%
Federal, total	16,901	16,873	16,373	15,846	15,889	15,521	15,905	16,688	-213	-1.3%
Chemical engineering										
Total, all sources	6,079	6,136	5,985	5,939	5,821	5,630	5,593	5,865	-214	-3.5%
Federal, total	1,761	1,735	1,765	1,800	1,671	1,701	1,669	1,674	-87	-4.9%
Civil engineering										
Total, all sources	12,458	12,641	12,248	11,791	11,406	11,154	11,237	11,765	-693	-5.6%
Federal, total	1,982	2,090	1,970	1,886	1,807	1,670	1,668	1,933	-49	-2.5%
Electrical engineering										
Total, all sources	20,343	19,385	18,167	17,967	18,854	19,470	20,219	22,821	2,478	12.2%
Federal, total	4,104	4,085	4,056	3,984	4,389	4,316	4,600	5,021	917	22.3%
Industrial engineering										
Total, all sources	5,950	5,960	5,389	5,166	5,116	4,894	5,500	6,089	139	2.3%
Federal, total	647	638	658	644	608	586	711	809	162	25.0%
Mechanical engineering										
Total, all sources	12,395	11,875	11,128	10,690	10,432	10,073	10,331	10,929	-1,466	-11.8%
Federal, total	2,999	2,946	2,777	2,602	2,626	2,607	2,591	2,660	-339	-11.3%
Other engineering										
Total, all sources	16,583	15,573	14,865	14,306	14,059	14,214	15,143	15,136	-1,447	-8.7%
Federal, total	5,408	5,379	5,147	4,930	4,788	4,641	4,666	4,591	-817	-15.1%
Health fields, total										
Total, all sources	35,799	39,174	42,192	44,595	46,721	48,581	50,510	50,095	14,296	39.9%
Federal, total	7,313	7,788	7,912	7,413	7,731	7,949	8,458	8,371	1,058	14.5%

SOURCE: RAND, based on NSF, Graduate Students and Postdoctorates in Science and Engineering, Fall 2000.

Table 19. Science and Engineering Doctorates Awarded, by Field of Study: 1970-2000 (selected years)

Field	1970	1975	1980	1985	1986	1987	1988	1989	1990
All degrees	29,498	32,952	31,020	31,297	31,902	32,370	33,500	34,327	36,067
S&E	18,052	18,799	17,775	18,935	19,437	19,894	20,932	21,732	22,868
Natural sciences	8,556	8,103	7,864	8,436	8,483	8,655	9,172	9,185	9,763
Physical	3,893	3,076	2,521	2,934	3,120	3,238	3,350	3,261	3,524
Earth/atmospheric/ocean sciences	498	625	628	599	559	602	695	723	738
Biological and agricultural sciences	4,165	4,402	4,715	4,903	4,804	4,815	5,126	5,202	5,502
Mathematics and computer sciences	1,332	1,360	962	998	1,128	1,190	1,264	1,471	1,597
Mathematics	1,225	1,147	744	688	729	740	749	859	892
Computer sciences	107	213	218	310	399	450	515	612	705
Social and behavioral sciences	4,825	6,538	6,470	6,335	6,450	6,337	6,310	6,532	6,613
Psychology	1,890	2,751	3,098	3,118	3,126	3,173	3,074	3,208	3,281
Social sciences	2,935	3,787	3,372	3,217	3,324	3,164	3,236	3,324	3,332
Engineering	3,446	3,011	2,479	3,166	3,376	3,712	4,187	4,543	4,894
Chemical	457	396	316	504	531	584	685	712	658
Civil	366	361	306	391	429	477	531	538	553
Electrical	857	714	540	716	806	779	1,010	1,137	1,276
Mechanical	635	487	384	513	536	657	715	760	884
Materials	303	272	273	303	305	392	374	380	440
Other	828	781	660	739	769	823	872	1,016	1,083

Field	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
All degrees	37,534	38,890	39,800	41,034	41,742	42,413	42,545	42,634	41,060	41,368
S&E	24,023	24,675	25,443	26,205	26,534	27,228	27,240	27,277	25,913	25,979
Natural sciences	10,164	10,437	10,530	11,082	11,032	11,391	11,414	11,517	10,929	10,966
Physical	3,626	3,781	3,699	3,977	3,841	3,837	3,768	3,823	3,578	3,411
Earth/atmospheric/ocean sciences	815	794	771	824	780	794	878	814	805	757
Biological and agricultural sciences	5,723	5,862	6,060	6,281	6,411	6,760	6,768	6,880	6,546	6,798
Mathematics and computer sciences	1,839	1,927	2,026	2,021	2,187	2,043	2,035	2,102	1,936	1,909
Mathematics	1,039	1,058	1,146	1,118	1,190	1,122	1,123	1,177	1,083	1,048
Computer sciences	800	869	880	903	997	921	910	925	853	861
Social and behavioral sciences	6,806	6,873	7,189	7,280	7,307	7,489	7,679	7,731	7,720	7,774
Psychology	3,250	3,263	3,420	3,379	3,429	3,491	3,568	3,676	3,659	3,623
Social sciences	3,556	3,610	3,769	3,901	3,878	3,998	4,111	4,055	4,061	4,151
Engineering	5,214	5,438	5,698	5,822	6,008	6,305	6,114	5,927	5,328	5330
Chemical	691	725	737	725	708	798	767	775	673	726
Civil	575	594	624	684	656	697	656	650	583	558
Electrical	1,405	1,483	1,543	1,673	1,731	1,740	1,721	1,596	1,477	1,544
Mechanical	875	987	1,030	1,015	1,025	1,052	1,021	1,023	854	864
Materials	489	485	535	539	588	572	581	565	469	451
Other	1,179	1,164	1,229	1,186	1,300	1,446	1,368	1,320	1,274	1,187

NOTE: Physical sciences include physics, chemistry, and astronomy.

SOURCE: RAND, based on NSF, Science & Engineering Indicators – 2002; and NSF, Science and Engineering Doctorate Awards: 2000

Table 20. Science and Engineering Doctorates Awarded, by Detailed Field of Study and Year of Doctorate: 1991-2000

Field of study	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Science and engineering, total	24,023	24,675	25,443	26,205	26,534	27,228	27,240	27,277	25,913	25,979
Sciences, total	18,809	19,237	19,745	20,383	20,526	20,923	21,126	21,350	20,585	20,649
Physical sciences, total	3,626	3,781	3,699	3,977	3,841	3,837	3,768	3,823	3,578	3,411
Astronomy	125	134	145	144	173	192	198	207	159	187
Chemistry	2,194	2,214	2,137	2,257	2,162	2,148	2,147	2,215	2,132	1,990
Physics	1,286	1,403	1,399	1,548	1,479	1,484	1,401	1,377	1,270	1,205
Earth, atmospheric, and ocean sciences, total	815	794	771	824	780	794	878	814	805	757
Atmospheric sciences	108	120	99	129	130	125	149	125	124	143
Geosciences	560	503	479	509	454	452	489	504	452	385
Oceanography	112	114	125	125	115	134	144	112	130	135
Mathematics	1,039	1,058	1,146	1,118	1,190	1,122	1,123	1,177	1,083	1,048
Computer sciences	800	869	880	903	997	921	910	925	853	861
Agricultural sciences	1,073	1,063	968	1,078	1,036	1,037	982	1,037	965	943
Biological sciences	4,650	4,799	5,092	5,203	5,375	5,723	5,786	5,843	5,581	5,855
Psychology	3,250	3,263	3,420	3,379	3,429	3,491	3,568	3,676	3,659	3,623
Social sciences, total	3,556	3,610	3,769	3,901	3,878	3,998	4,111	4,055	4,061	4,151
Economics	1,053	1,051	1,067	1,101	1,152	1,177	1,163	1,155	1,075	1,085
Political science	740	804	824	930	894	927	974	961	1,017	986
Sociology	493	512	535	548	555	527	601	579	571	634
Other social sciences	1,270	1,243	1,343	1,322	1,277	1,367	1,373	1,360	1,398	1,446
Engineering, total	5,214	5,438	5,698	5,822	6,008	6,305	6,114	5,927	5,328	5,330
Aeronautical/astronautical engineering	207	234	228	230	252	287	273	243	206	215
Chemical engineering	691	725	737	725	708	798	767	775	673	726
Civil engineering	575	594	624	684	656	697	656	650	583	558
Electrical engineering	1,405	1,483	1,543	1,673	1,731	1,740	1,721	1,596	1,477	1,544
Industrial/manufacturing engineering	165	196	236	228	284	258	246	229	212	176
Materials/metallurgical engineering	489	485	535	539	588	572	581	565	469	451
Mechanical engineering	875	987	1,030	1,015	1,025	1,052	1,021	1,023	854	864
Other engineering	807	734	765	728	764	901	849	846	854	796
Health, total	1,041	1,112	1,197	1,296	1,330	1,324	1,422	1,501	1,404	1,589

SOURCE: RAND, based on National Science Foundation/Division of Science Resources Statistics, Science and Engineering Doctorate Awards: 2000.

Table 21. S&E and Health Doctorates Earned by U.S. Citizens and Noncitizens: 1980–2000

Year	U.S. Citizens	U.S. citizens, white women	U.S. citizens, white men	U.S. citizens, minority men and women	Noncitizens*
1980	13,438	3,334	9,262	842	3,790
1981	13,786	3,537	9,353	896	3,970
1982	13,748	3,663	9,139	946	4,127
1983	13,807	3,946	8,910	951	4,433
1984	13,737	4,025	8,670	1,042	4,660
1985	13,409	3,985	8,418	1,006	5,112
1986	13,379	4,158	8,162	1,059	5,288
1987	13,326	4,135	8,080	1,111	5,693
1988	13,817	4,391	8,264	1,162	6,219
1989	13,987	4,709	8,072	1,206	6,676
1990	14,678	4,907	8,489	1,282	7,969
1991	15,126	5,193	8,424	1,509	9,157
1992	15,177	5,152	8,465	1,560	9,747
1993	15,689	5,453	8,567	1,669	10,028
1994	16,004	5,640	8,607	1,757	10,861
1995	16,266	5,686	8,554	2,026	10,855
1996	16,398	5,832	8,503	2,063	11,165
1997	16,673	5,919	8,426	2,328	10,120
1998	16,948	6,167	8,413	2,368	10,170
1999	16,547	5,895	8,138	2,514	9,250
2000	16,390	6,014	7,814	2,562	9,438

*Noncitizens include both non-U.S. citizens with permanent visas and non-U.S. citizens with temporary visas.

SOURCE: RAND, based on National Science Board, Science & Engineering Indicators—2002; and National Science Foundation, Science and Engineering Doctorate Awards: 2000

Table 22. Doctoral Degrees in the United States and Selected Countries in Europe and Asia: 1988–1999

Field	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
United States												
Total	33,500	34,327	36,067	37,534	38,890	39,801	41,034	41,743	42,414	42,555	42,683	41,140
Total S&E	20,932	21,731	22,868	24,023	24,675	25,443	26,205	26,535	27,229	27,245	27,309	25,953
Natural sciences	8239	8220	8589	9086	9372	9561	10001	9988	10354	10432	10497	9989
Math & computer sciences	1,264	1,471	1,597	1,839	1,927	2,026	2,021	2,187	2,043	2,035	2102	1935
Agricultural sciences	933	965	1,174	1,073	1,063	968	1,078	1,036	1,037	982	1037	965
Social/behavioral sciences	6,310	6,532	6,613	6,806	6,873	7,190	7,280	7,307	7,490	7,682	7743	7727
Engineering	4,187	4,543	4,894	5,214	5,438	5,698	5,822	6,008	6,305	6,114	5930	5337
Non-S&E	12,568	12,596	13,199	13,511	14,215	14,358	14,829	15,208	15,185	15,310	15,374	15,187
France												
Total	NA	5,963	6,782	7,198	8,585	9,295	10,602	9,801	10,963	11,073	10,582	NA
Total S&E	NA	4,888	5,158	5,384	6,377	6,820	7,555	7,027	8,511	8,962	8,359	NA
Natural sciences	NA	2,615	2,841	2,883	3,525	3,631	3,866	3,572	4,052	4,394	3,924	NA
Math & computer sciences	NA	722	795	831	976	1,065	1,203	1,129	1,241	869	845	NA
Agricultural sciences	NA	37	53	38	38	52	94	84	194	207	179	NA
Social/behavioral sciences	NA	672	488	539	663	797	1,018	815	1,285	1,629	1,559	NA
Engineering	NA	842	981	1,093	1,175	1,275	1,374	1,427	1,739	1,863	1,852	NA
Non-S&E	NA	1,075	1,624	1,814	2,208	2,475	3,047	2,774	2,452	2,111	2,223	NA
Germany												
Total	17,321	17,901	22,372	22,462	21,438	22,000	22,000	22,387	22,849	24,174	24,890	24,545
Total S&E	7,101	7,568	10,762	10,465	10,148	10,200	10,200	10,889	11,472	11,728	11,966	11,984
Natural sciences	3,844	4,095	5,319	5,326	5,638	5,700	5,700	5,868	6,078	6,418	6,625	6,271
Math & computer sciences	332	383	429	418	464	500	500	663	810	785	855	980
Agricultural sciences	450	518	997	709	602	500	500	507	512	521	562	522
Social/behavioral sciences	1,150	1,200	1,544	1,483	1,344	1,400	1,400	1,741	1,803	1,775	1,824	1,982
Engineering	1,325	1,372	2,473	2,529	2,100	2,100	2,100	2,110	2,269	2,229	2,100	2,229
Non-S&E	10,220	10,333	11,610	11,997	11,290	11,800	11,800	11,498	11,377	12,446	12,924	12,561
United Kingdom												
Total	7,588	7,845	8,242	8,387	8,396	8,717	9,000	7,557	9,761	10,214	10,993	11,338
Total S&E	5,663	5,816	6,207	6,302	6,112	6,098	6,325	5,134	6,526	6,765	7,268	7,386
Natural sciences	2,787	2,937	3,113	3,151	3,054	3,034	3,200	2,580	3,380	3,421	3,665	3,668
Math & computer sciences	374	415	471	535	519	528	600	454	602	586	565	680
Agricultural sciences	244	238	241	248	279	275	325	271	351	324	392	326
Social/behavioral sciences	899	878	916	914	935	739	700	502	636	679	809	907
Engineering	1,359	1,348	1,466	1,454	1,325	1,522	1,500	1,327	1,557	1,755	1,837	1,805
Non-S&E	1,925	2,029	2,035	2,085	2,284	2,619	2,675	2,423	3,235	3,449	3,725	3,952
China												
Total	1,682	1,904	2,127	2,556	2,540	2,114	3,590	4,364	4,950	6,793	8,518	10,160
Total S&E	797	1,024	1,069	1,198	1,357	1,895	2,741	3,417	4,428	5,328	6,358	6,778
Natural sciences	165	141	209	252	304	528	918	1,191	1,479	1,678	2,246	2,135
Math & computer sciences	75	78	89	95	101	103	139	187	264	334	350	417
Agricultural sciences	55	56	20	37	68	92	125	182	256	328	416	444
Social/behavioral sciences	26	23	36	47	61	102	170	198	234	325	446	513
Engineering	476	726	715	767	823	1,069	1,389	1,659	2,195	2,643	2,900	3,269
Non-S&E	885	880	1,058	1,358	1,183	219	849	947	522	1,465	2,160	3,382

Table 22. Doctoral Degrees in the United States and Selected Countries in Europe and Asia: 1988-1999 (continued)

Field	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
India												
Total	7,598	8,284	8,586	8,374	8,383	8,720	9,923	9,070	10,397	10,408	10,408	NA
Total S&E	4,208	4,209	4,166	4,212	4,183	4,021	4,565	4,000	5,015	4,764	4,764	NA
Natural sciences	3,038	3,044	2,976	2,950	3,044	2,997	3,467	2,950	3,861	3,498	3,498	NA
Math & computer sciences	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Agricultural sciences	576	579	583	633	688	701	769	715	780	968	968	NA
Social/behavioral sciences	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Engineering	594	586	607	629	451	323	329	335	374	298	298	NA
Non-S&E	3,390	4,075	4,420	4,162	4,200	4,699	5,358	5,070	5,382	5,644	5,644	NA
Japan												
Total	9,602	10,036	10,633	10,758	10,885	11,576	12,160	12,645	13,820	13,921	14,800	NA
Total S&E	3,511	3,561	3,704	3,874	4,056	4,438	4,877	5,205	6,006	6,157	6,575	NA
Natural sciences	881	876	835	863	892	1,009	1,132	1,182	1,243	1,315	1,481	NA
Math & computer sciences	0	0	0	0	0	0	0	0	0	0	NA	NA
Agricultural sciences	746	734	719	791	870	824	894	956	1,108	1,043	1,094	NA
Social/behavioral sciences	167	177	183	191	200	243	241	276	358	388	420	NA
Engineering	1,717	1,774	1,967	2,029	2,094	2,362	2,610	2,791	3,297	3,411	3,580	NA
Non-S&E	6,091	6,475	6,929	6,884	6,829	7,138	7,283	7,440	7,814	7,764	8,225	NA
South Korea												
Total	2,125	2,458	2,481	2,984	3,211	3,583	3,999	4,462	4,723	4,999	5,586	NA
Total S&E	871	984	945	1,135	1,228	1,421	1,650	1,920	2,046	2,189	2,484	NA
Natural sciences	207	192	170	225	202	244	296	358	391	427	375	NA
Math & computer sciences	73	105	75	99	106	124	145	169	178	187	209	NA
Agricultural sciences	155	175	154	156	151	172	196	223	199	178	180	NA
Social/behavioral sciences	90	97	107	189	217	222	227	232	236	240	327	NA
Engineering	346	415	439	466	552	659	786	938	1,042	1,157	1,393	NA
Non-S&E	1,254	1,474	1,536	1,849	1,983	2,162	2,349	2,542	2,677	2,810	3,102	NA
Taiwan												
Total	249	314	410	410	608	701	808	848	1,053	1,187	1,282	1,337
Total S&E	197	257	312	370	450	513	592	650	783	839	907	892
Natural sciences	35	42	47	62	82	97	115	115	154	163	172	150
Math & computer sciences	14	18	24	32	42	45	49	55	63	88	93	119
Agricultural sciences	28	36	33	36	39	48	60	63	65	79	78	76
Social/behavioral sciences	22	41	43	31	23	36	56	44	66	76	87	65
Engineering	98	120	165	209	264	287	312	373	435	433	477	482
Non-S&E	52	57	98	40	158	188	216	198	270	348	375	445

NA = not available

NOTE: Natural sciences include physics, chemistry, astronomy, and biological, earth, atmospheric, and ocean sciences.

In Japanese higher education data, mathematics is included in natural sciences; computer science is included in engineering.

SOURCE: RAND, based on National Science Board, Science & Engineering Indicators —2002

Table 23. Employed doctoral scientists and engineers, by field of doctorate and age: 1993-1999

Field and year	Total	Under 35	36-39	40-44	45-49	50-54	55-59	60-64	65-75
	Number	Percent							
Total									
1993	462,870	9.9	15.6	17.7	18.9	17.3	9.8	6.0	4.6
1995	484,780	9.7	15.3	17.2	18.6	17.4	11.1	6.0	4.7
1997	518,440	12.4	14.2	16.7	17.1	17.2	12.1	5.9	4.3
1999	553,360	9.7	14.4	15.8	16.2	16.3	14.7	7.8	5.1
Sciences									
1993	387,760	9.1	15.5	18.3	19.4	17.3	9.4	6.1	4.8
1995	406,110	8.9	14.4	17.3	19.5	17.8	11.0	6.0	4.9
1997	429,820	11.5	13.4	17.0	18.1	17.7	12.1	5.7	4.5
1999	457,470	8.8	13.5	15.6	17.0	17.2	15.0	7.6	5.3
Computer/math sciences									
1993	27,950	12.7	15.6	15.8	19.1	19.5	9.6	4.2	3.4
1995	29,270	11.5	16.3	15.8	18.6	18.7	11.6	5.4	2.0
1997	32,400	15.9	15.3	15.0	15.5	18.3	12.2	5.0	2.7
1999	34,900	11.9	16.4	16.2	14.6	14.8	15.6	7.0	3.2
Computer/information sciences									
1993	5,150	27.8	30.8	24.0	12.2	3.9	S	S	S
1995	6,450	20.5	33.9	23.4	14.1	6.1	1.5	S	S
1997	8,000	26.3	27.8	21.0	16.2	7.5	0.8	S	S
1999	9,600	15.3	27.9	23.8	18.8	10.2	3.4	S	S
Mathematical sciences									
1993	22,800	9.3	12.2	14.0	20.7	23.0	11.6	5.0	4.1
1995	22,820	8.9	11.3	13.7	19.9	22.2	14.5	6.9	2.5
1997	24,400	12.5	11.2	13.0	15.3	21.8	15.9	6.6	3.5
1999	25,300	10.7	12.1	13.3	13.1	16.6	20.2	9.7	4.4
Biological/agricultural sciences									
1993	110,920	9.7	18.5	19.3	18.6	15.7	8.5	5.7	3.9
1995	116,690	9.9	15.8	19.6	18.6	16.2	9.8	5.7	4.3
1997	124,600	12.9	14.6	19.6	17.7	15.9	10.2	5.4	3.9
1999	134,360	10.2	15.1	17.5	18.0	15.3	13.2	6.1	4.6
Agricultural/food sciences									
1993	15,100	8.3	19.1	19.0	15.0	15.9	9.6	7.9	5.3
1995	15,440	7.5	13.7	21.7	16.8	16.7	10.5	8.0	5.1
1997	15,670	7.8	13.5	23.4	17.1	14.4	12.6	5.8	5.3
1999	16,560	5.0	14.1	20.6	20.2	15.1	13.2	6.9	4.8
Biological sciences									
1993	91,970	10.3	18.5	19.3	18.9	15.5	8.3	5.4	3.8
1995	97,370	10.6	16.3	19.2	18.5	15.9	9.8	5.2	4.3
1997	104,630	14.0	14.9	19.0	17.6	15.8	9.7	5.3	3.7
1999	112,840	11.2	15.4	17.2	17.5	15.0	13.0	6.1	4.6
Environmental life sciences									
1993	3,850	2.8	14.5	19.4	24.8	20.6	9.3	5.9	2.7
1995	3,890	2.4	11.9	19.3	27.7	22.2	7.4	8.1	S
1997	4,300	3.6	12.9	19.3	22.2	23.4	11.7	5.3	1.6
1999	4,970	4.1	11.0	14.1	20.9	22.4	19.0	4.4	4.1
Health sciences									
1993	13,670	5.1	13.1	24.8	22.7	17.0	9.3	4.5	3.3
1995	15,460	5.2	11.3	22.9	23.3	17.9	10.3	5.8	3.3
1997	17,180	7.5	11.1	19.7	23.5	18.9	11.2	5.2	2.8
1999	19,310	6.0	9.9	13.4	21.3	23.1	16.3	6.6	3.4

Table 23. Employed doctoral scientists and engineers, by field of doctorate and age: 1993-1999 (continued)

Field and year	Total	Under 35	36-39	40-44	45-49	50-54	55-59	60-64	65-75
	Number	Percent							
Physical/related sciences									
1993	98,540	11.9	15.4	14.5	16.3	18.1	10.9	7.3	5.6
1995	101,300	11.6	15.8	14.5	15.5	17.1	13.2	6.4	5.9
1997	105,250	14.0	15.1	14.7	13.7	16.4	14.4	6.3	5.4
1999	110,300	10.2	16.1	15.8	12.9	14.5	15.5	9.1	5.8
Chemistry, except biochem									
1993	51,760	13.5	16.5	13.6	15.2	17.4	10.5	7.6	5.7
1995	52,530	12.4	16.7	14.9	13.6	16.4	13.5	6.3	6.3
1997	54,220	14.9	16.0	15.7	12.1	15.5	14.3	6.0	5.6
1999	55,810	11.1	16.4	16.7	13.0	13.4	15.0	8.9	5.4
Earth/atmos/ocean sciences									
1993	13,620	9.2	16.4	18.7	18.9	15.5	10.8	7.0	3.5
1995	14,370	8.7	16.8	16.8	20.5	14.7	11.3	6.3	4.8
1997	15,110	8.6	17.3	17.9	17.1	18.3	10.7	5.8	4.2
1999	15,940	5.7	15.5	18.8	16.8	17.2	13.1	8.1	4.8
Physics and astronomy									
1993	33,150	10.4	13.3	14.1	17.1	20.2	11.7	6.9	6.3
1995	34,410	11.7	14.1	13.0	16.3	19.1	13.6	6.5	5.7
1997	35,920	15.0	12.9	11.7	14.7	17.0	16.1	6.9	5.6
1999	38,560	10.8	15.8	13.3	11.2	15.1	17.2	10.0	6.6
Social sciences									
1993	65,660	5.3	12.0	17.9	21.0	21.0	9.9	6.9	5.7
1995	67,600	5.0	11.5	15.2	21.2	21.5	12.3	6.8	6.3
1997	71,070	7.5	10.5	14.9	20.2	20.4	14.7	6.5	5.2
1999	74,300	5.8	9.8	13.2	17.2	19.9	18.4	9.3	6.5
Economics									
1993	19,410	7.8	15.5	15.5	20.4	17.8	9.2	7.0	6.3
1995	19,860	7.7	14.7	15.1	19.1	18.3	12.4	5.5	6.8
1997	20,080	10.2	12.0	16.2	19.5	18.5	13.0	5.3	5.2
1999	21,190	8.0	11.3	15.1	14.8	18.4	17.1	9.0	6.1
Political/related sciences									
1993	14,290	3.7	10.2	16.9	19.8	23.2	10.1	9.2	6.7
1995	14,780	5.0	9.9	14.1	21.9	21.6	10.9	8.4	7.9
1997	15,820	7.8	9.4	13.6	16.4	23.4	14.8	8.7	5.9
1999	16,090	7.2	10.3	11.9	15.4	19.0	18.8	8.8	8.6
Sociology									
1993	12,200	4.2	8.4	18.0	20.8	20.7	13.2	6.8	7.3
1995	12,210	2.9	7.6	14.7	20.8	23.7	15.5	6.6	8.0
1997	13,230	4.6	7.4	13.5	21.6	20.8	16.8	9.2	6.1
1999	13,420	5.3	7.4	10.2	17.4	21.1	19.6	11.5	7.4
Other social sciences									
1993	19,760	4.7	12.0	20.8	22.4	22.9	8.4	5.2	3.6
1995	20,750	6.9	12.8	19.0	24.2	17.7	8.9	5.8	4.7
1997	21,940	6.7	11.8	15.4	22.9	19.8	15.1	4.4	4.0
1999	23,590	3.1	9.6	13.9	20.4	21.1	18.4	8.8	4.8
Psychology									
1993	71,020	7.4	14.6	22.1	23.0	14.5	8.2	5.4	4.8
1995	75,790	6.9	12.8	19.0	24.2	17.7	8.9	5.8	4.7
1997	79,320	8.7	11.4	18.3	22.5	19.1	9.9	5.1	5.0
1999	84,300	6.9	10.6	14.7	20.4	20.9	13.7	6.7	6.0

Table 23. Employed doctoral scientists and engineers, by field of doctorate and age: 1993-1999 (continued)

Field and year	Total	Under 35	36-39	40-44	45-49	50-54	55-59	60-64	65-75
	Number	Percent							
Engineering									
1993	75,110	13.6	16.3	14.9	16.4	17.5	12.1	5.4	3.9
1995	78,620	13.7	20.0	16.5	14.1	15.4	11.4	5.5	3.5
1997	88,620	16.5	18.3	15.0	12.5	15.2	12.4	6.8	3.3
1999	95,890	13.8	18.5	16.7	12.8	12.3	13.2	8.6	4.1
Aerospace/aeronautical									
1993	3,050	11.3	9.8	14.9	13.7	21.7	20.8	4.6	3.2
1995	3,350	14.0	16.8	10.8	14.0	19.6	15.2	7.7	1.9
1997	3,720	20.2	14.4	6.6	14.2	17.9	15.7	8.1	2.8
1999	4,360	19.4	13.6	11.5	8.5	10.3	14.1	14.2	8.4
Chemical									
1993	11,140	17.1	17.5	11.3	15.5	16.5	14.3	4.0	3.7
1995	10,930	16.8	20.9	15.0	12.5	15.2	11.6	4.5	3.5
1997	12,280	18.1	18.1	14.4	9.7	16.3	11.7	8.2	3.5
1999	12,520	15.8	18.4	19.2	9.9	11.3	13.5	8.4	3.5
Civil									
1993	7,060	10.3	15.8	11.9	17.8	19.7	14.5	6.5	3.4
1995	7,400	10.2	18.4	16.3	12.8	17.9	11.8	8.4	4.3
1997	8,190	12.8	17.1	15.5	11.6	14.7	15.2	9.5	3.6
1999	8,700	8.7	16.4	15.0	11.8	15.0	16.7	10.3	6.1
Electrical/computer									
1993	19,400	15.2	16.8	13.8	17.4	17.8	10.9	4.6	3.5
1995	20,770	16.2	20.3	16.1	13.4	16.3	10.6	4.5	2.7
1997	23,750	20.1	18.7	14.2	10.8	14.9	11.8	6.3	3.3
1999	25,980	14.8	21.2	15.8	12.2	11.0	12.1	9.3	3.7
Materials/metallurgical									
1993	7,200	16.2	17.3	19.7	12.8	11.9	10.1	7.2	4.7
1995	7,850	16.3	22.5	19.8	11.4	11.9	9.9	4.6	3.6
1997	8,510	18.3	19.5	19.9	13.6	8.9	12.3	5.0	2.6
1999	9,970	18.7	21.0	16.9	15.4	9.0	10.6	5.4	3.1
Mechanical									
1993	9,470	14.2	19.4	15.9	15.9	15.6	11.0	4.6	3.4
1995	9,710	12.5	23.3	18.0	14.7	12.9	9.7	6.0	2.9
1997	11,080	16.3	22.6	16.3	13.7	13.4	9.3	6.1	2.1
1999	12,780	14.6	19.6	20.0	12.4	14.0	9.7	6.4	3.4
Other engineering									
1993	17,790	9.8	14.4	17.3	17.3	19.4	10.8	6.5	4.5
1995	18,620	9.9	17.6	16.7	17.2	15.5	12.7	5.6	4.7
1997	21,100	11.6	16.3	15.1	14.8	18.2	13.5	6.5	3.9
1999	21,580	9.9	15.3	15.8	15.5	14.3	16.2	8.7	4.2

KEY: S=Suppressed due to too few cases (fewer than 50 weighted cases).

NOTE: Numbers are rounded to nearest ten.

SOURCE: RAND, based on NSF, Characteristics of Doctoral Scientists and Engineers: 1999; and Selected Trends Tables 1993, 1995, and 1997.

SUPPORTING TABLES FOR PCAST ISSUE 5

International Comparison

Table 24. International R&D Expenditures, by Selected Country and for all OECD Countries: 1981–99
[billions of constant 1996 U.S. dollars[a]]

Year	United States	Japan[b]	Germany[c]	France	United Kingdom	Italy	Canada	Russian Federation	Total OECD
1981	115.9	36.5	25.3	17.6	18.3	7.3	5.6	NA	250.9
1982	122.0	39.2	26.0	18.8	NA	7.5	6.0	NA	262.1
1983	130.8	42.6	26.6	19.5	17.9	8.1	6.1	NA	277.0
1984	143.3	46.2	27.6	20.7	NA	8.9	6.7	NA	299.6
1985	155.8	51.4	30.5	21.7	19.6	10.2	7.3	NA	326.5
1986	159.8	52.4	31.6	22.0	20.7	10.6	7.7	NA	337.3
1987	162.8	56.2	33.4	23.0	21.1	11.5	7.8	NA	350.0
1988	167.0	60.8	34.7	24.1	21.7	12.2	8.0	NA	364.4
1989	170.4	66.8	36.3	25.8	22.5	12.9	8.2	NA	380.5
1990	175.8	72.7	36.9	27.5	23.0	13.8	8.7	NA	398.3
1991	179.5	74.7	39.6	27.9	21.3	13.5	8.9	21.0	412.6
1992	180.1	75.2	40.0	28.7	22.4	13.4	9.2	9.6	420.5
1993	176.2	73.5	38.5	28.1	22.6	12.2	9.8	9.2	415.4
1994	176.2	72.8	38.6	27.6	22.7	11.8	10.5	8.9	418.8
1995	187.2	80.2	40.2	28.3	22.1	11.7	11.3	7.8	449.4
1996	197.3	84.7	39.9	27.8	22.5	12.1	11.1	8.8	468.0
1997	208.3	87.2	41.0	26.6	22.2	11.7	11.5	9.6	484.9
1998	219.8	88.9	42.2	26.9	22.7	12.2	12.0	9.0	502.0
1999	233.0	88.8	44.1	27.6	23.6	12.7	12.2	NA	NA

NA = not available

[a]Conversions of foreign currencies to U.S. dollars are calculated with OECD purchasing power parity exchange rates. Constant 1996 dollars are based on the U.S. GDP implicit price deflator.

[b]Data on Japanese R&D in 1996 and later years may not be consistent with data in earlier years because of changes in methodology.

[c]Data for 1981–90 are for West Germany.

SOURCE: National Science Board, Science & Engineering Indicators—2002

Table 25. Sources of R&D Expenditures in OECD Countries
[percent]

	Sources of total R&D		
	Government	Industry	Other
1982	44.5	51.9	3.6
1983	43.9	52.5	3.6
1984	43	53.3	3.7
1985	42.4	53.9	3.7
1986	42.1	54.1	3.8
1987	42	53.9	4.1
1988	40.5	55.3	4.2
1989	38.8	56.7	4.5
1990	37.8	57.5	4.7
1991	35.5	59	5.5
1992	34.9	59.4	5.7
1993	35.1	59	5.9
1994	34.4	59.3	6.3
1995	33.8	59.9	6.3
1996	32.2	61.3	6.5
1997	31.1	62.3	6.6
1998	30.7	62.5	6.8

SOURCE: National Science Board, Science & Engineering Indicators—2002

Table 26. R&D Expenditures by Performer and Source, G-8 countries[a]

Country and R&D performer	Total	Industry	Government	Higher education	Private nonprofit	Abroad	Percent distribution, performers
	Sources of R&D funds						
			Billions of yen				
Japan, 1998	15,169	11,008	2,921	1,092	100	48	100.0
Industry	10,800	10,513	223	—	17	47	71.2
Government	1,403	21	1,382	—	—	—	9.2
Higher education	2,252	51	1,107	1,091	3	—	14.8
Private nonprofit	714	423	209	1	80	1	4.7
Percent distribution, sources	100.0	72.6	19.3	7.2	0.7	0.3	na
			Millions of deutsch marks				
Germany, 1999	92,230	58,570	31,180	0	310	2,170	100.0
Industry	63,300	56,640	5,000	—	60	1,600	68.6
Government	13,210	270	12,450	—	250	240	14.3
Higher education	15,720	1,660	13,750	—	—	310	17.0
Private nonprofit	—	—	—	—	—	—	0.0
Percent distribution, sources	100.0	63.5	33.8	0.0	0.3	2.4	na
			Millions of francs				
France, 1998	185,943	99,489	69,350	1,654	1,702	13,748	100.00
Industry	115,839	94,542	10,397	11	62	10,827	62.30
Government	34,627	3,246	29,509	78	39	1,755	18.60
Higher education	32,708	1098	29,084	1,473	122	931	17.60
Private nonprofit	2,769	603	361	91	1,479	235	1.50
Percent distribution, sources	100.0	53.5	37.3	0.9	0.9	7.4	na
			Millions of pounds				
United Kingdom, 1998	15,553	7,351	4,832	130	621	2,619	100.00
Industry	10,261	6,826	1,190	—	0	2,245	66.00
Government	2,079	297	1,653	6	46	77	13.40
Higher education	3,040	221	1,959	122	463	275	19.50
Private nonprofit	203	38	30	2	113	20	1.30
Percent distribution, sources	100.0	47.3	31.1	0.8	4.0	16.8	na
			Billions of lire				
Italy, 1999	22,202	9,739	11,345	0	0	1,118	100.0
Industry	11,938	9,367	1,587	—	—	984	53.8
Government	4,697	106	4,504	—	—	87	21.2
Higher education	5,566	265	5,254	—	—	47	25.1
Private nonprofit	—	—	—	—	—	—	0.0
Percent distribution, sources	100.0	43.9	51.1	0.0	0.0	5.0	na
			Millions of Canadian dollars				
Canada, 1999	14,911	7,343	4,658	438	416	2,056	100.0
Industry	9,387	6,888	497	—	—	2,002	63.0
Government	1,823	51	1,767	—	—	5	12.2
Higher education	3,523	380	2,341	438	326	38	23.6
Private nonprofit	178	24	53	—	90	11	1.2
Percent distribution, sources	100.0	49.2	31.2	2.9	2.8	13.8	na
			Billions of rubles				
Russian Federation, 1998	25,082	8,755	13,436	87	231	2,573	100.0
Industry	17,297	7,908	7,438	13	22	1,916	69.0
Government	6,466	521	5,150	4	205	586	25.8
Higher education	1,297	320	837	69	3	68	5.2
Private nonprofit	22	6	12	—	2	3	0.1
Percent distribution, sources	100.0	34.9	53.6	0.3	0.9	10.3	na
			Millions of U.S. dollars				
United States, 1999	244,143	163,397	69,794	5,562	5,390	—	100.0
Industry	180,450	160,288	20,162	—	—	—	73.9
Government	27,312	—	27,312	—	—	—	11.2
Higher education	28,363	2,133	18,601	5,562	2,066	—	11.6
Private nonprofit	8,017	976	3,718	—	3,323	—	3.3
Percent distribution, sources	100.0	66.9	28.6	2.3	2.2	—	na

[a]The G-8 countries are the G-7 countries, Canada, France, Germany, Italy, Japan, the United Kingdom and the United States, plus the Russia Federation

SOURCE: National Science Board, Science & Engineering Indicators—2002.

Table 27. Academic R&D Expenditures, by Country and Source of Funds
[percent]

Country and source of funds	1981[a]	1990	1999[b]
Canada			
Government…………	79.8	73.2	66.4
Other………………….	16.4	20.9	22.8
Industry.....................	3.9	5.9	10.8
France			
Government…………	97.7	92.9	88.9
Other………………….	1.0	2.2	7.7
Industry.....................	1.3	4.9	3.4
Germany			
Government…………	98.2	92.1	87.5
Other………………….	0.0	0.0	2.0
Industry.....................	1.8	7.9	10.6
Italy			
Government…………	96.2	96.7	94.4
Other………………….	1.1	0.9	0.9
Industry.....................	2.7	2.4	4.8
Japan			
Government…………	57.7	51.2	49.1
Other………………….	41.3	46.5	48.5
Industry.....................	1.0	2.3	2.3
United Kingdom			
Government…………	81.3	73.5	64.4
Other………………….	15.9	19.0	28.3
Industry.....................	2.8	7.6	7.3
United States			
Government…………	74.1	66.9	65.6
Other………………….	21.5	26.2	26.9
Industry.....................	4.4	6.9	7.3
Russian Federation			
Government…………	NA	NA	64.5
Other………………….	NA	NA	10.8
Industry.....................	NA	NA	24.7

NA = not available

[a]Canada data are for 1983.

[b]France, Japan, and United Kingdom data are for 1998.

SOURCE: RAND, based on National Science Board, Science & Engineering Indicators—2002.

Table 28. Distribution of Government R&D Budget Appropriations in G-8 Countries, by Socioeconomic Objective: 1998 or 1999
[percent]

Socioeconomic objective	United States (1999)	Japan (1999)	Germany (1999)	France (1999)	United Kingdom (1999)	Italy (1998)	Russian Federation (1998)	Canada (1998)
Total (millions U.S. dollars[a])	77,640	19,758	15,956	12,815	8,918	7,164	3,874	3,575
Agriculture, forestry, and fishing	2.1	3.5	2.6	3.0	4.5	1.9	5.2	11.0
Industrial development	0.6	6.5	12.7	6.2	1.5	8.1	23.3	12.5
Energy	1.5	19.3	3.6	4.9	0.5	5.0	3.9	5.4
Infrastructure	2.3	3.5	1.7	0.6	1.9	0.6	2.1	3.9
Transport and telecommunications	2.2	2.2	0.8	NA	0.5	NA	NA	3.9
Urban and rural planning	0.1	1.3	0.8	NA	1.4	NA	NA	NA
Environmental protection	0.7	0.7	3.5	1.6	2.6	3.4	1.8	3.1
Health	20.9	3.7	3.3	5.5	14.9	5.6	2.5	8.9
Social development and services	0.9	0.9	3.2	1.5	2.8	3.6	1.9	3.4
Earth and atmosphere	1.2	1.5	1.8	0.7	1.4	1.6	2.2	4.6
Advancement of knowledge	6.0	49.5	54.7	40.3	32.1	59.4	15.2	31.4
Advancement of research	6.0	12.8	16.1	22.0	13.2	11.6	15.2	7.9
General university funds[b]	NA	36.6	38.6	18.3	19.0	47.8	NA	23.5
Civil space	10.6	6.3	4.5	11.0	2.4	8.3	12.2	8.7
Defense	53.2	4.6	8.4	22.7	34.9	2.6	29.7	4.7
Not elsewhere classified	0.0	0.0	0.2	2.0	0.5	0.0	0.0	2.4

NA = not available separately
[a]Conversions of foreign currencies to U.S. dollars are calculated with OECD purchasing power parity exchange rates.
[b]The United States and the Russian Federation do not have an equivalent category to general university funds.
SOURCE: National Science Board, Science and Engineering Indicators—2002

APPENDIX II. REFERENCES

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