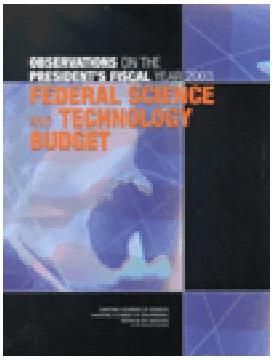

Observations on the President's Fiscal Year 2003 Federal Science and Technology Budget

Committee on the Federal Science and Technology Budget

ISBN: 0-309-50341-8, 52 pages, 8.5 x 11, (2002)

OBSERVATIONS ON THE PRESIDENT'S FISCAL YEAR 2003 FEDERAL SCIENCE AND TECHNOLOGY BUDGET

Committee on the FY 2003 Federal Science and Technology Budget

Committee on Science, Engineering, and Public Policy

NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING
INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS • 500 Fifth Street, N.W. • Washington, DC 20001

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

The National Research Council supported this study. It was prepared by Committee on the FY 2003 Federal Science and Technology Budget under the aegis of the Committee on Science, Engineering, and Public Policy (COSEPUP). COSEPUP is a joint committee of NAS, NAE, and IOM. It includes members of the councils of all three bodies.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 0-309-08538-1

This report is available on COSEPUP's World Wide Web site at http://www7.nationalacademies.org/cosepup

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, N.W., Lockbox 285, Washington, DC 20055; (800) 624-6242 or (202) 334-3313 (in the Washington metropolitan area); Internet, http://www.nap.edu

Printed in the United States of America

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Wm. A. Wulf is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Wm. A. Wulf are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

COMMITTEE ON THE FY 2003 FEDERAL SCIENCE AND TECHNOLOGY BUDGET

JAMES J. DUDERSTADT (Chair), President Emeritus and University Professor of Science and Engineering, Millennium Project, University of Michigan
DAVID CHALLONER, Vice President for Health Affairs Emeritus and Interim Chair, Department of Health Policy and Epidemiology, University of Florida
MILDRED DRESSELHAUS, Institute Professor of Electrical Engineering and Physics, Massachusetts Institute of Technology
JACK HALPERN, Louis Block Distinguished Service Professor of Chemistry Emeritus, University of Chicago
ANITA JONES, Lawrence Quarles Professor of Engineering and Applied Science, University of Virginia
SAMUEL PRESTON, Dean and Frederick J. Warren Professor of Demography, The University of Pennsylvania
PHILIP M. SMITH, Partner, McGeary and Smith
MARK WRIGHTON, Chancellor, Washington University in St. Louis

PETER H. HENDERSON, Study Director
ELIZABETH BRIGGS, Administrative Assistant

COMMITTEE ON SCIENCE, ENGINEERING, AND PUBLIC POLICY

MAXINE F. SINGER (Chair), President, Carnegie Institution of Washington
BRUCE M. ALBERTS (Ex-Officio), President, National Academy of Sciences
ENRIQUETA BOND, President, The Burroughs Wellcome Fund
R. JAMES COOK, R. James Cook Endowed Chair in Wheat Research, Washington State University
GERALD P. DINNEEN (Ex-Officio), Retired Vice President, Science and Technology, Honeywell, Inc.
JAMES J. DUDERSTADT, President Emeritus and University Professor of Science and Engineering, Millennium Project, University of Michigan
HARVEY V. FINEBERG (Ex-Officio), President, Institute of Medicine (since July 1, 2002)
MARYE ANNE FOX, Chancellor, North Carolina State University
RALPH E. GOMORY, President, Alfred P. Sloan Foundation
RUBY P. HEARN, Senior Vice President, The Robert Wood Johnson Foundation
SAMUEL PRESTON, Dean and Frederick J. Warren Professor of Demography, The University of Pennsylvania
GERALD M. RUBIN, Vice President for Biomedical Research, Howard Hughes Medical Institute
KENNETH I. SHINE (Ex-Officio), President, Institute of Medicine (through June 30, 2002)
EDWARD H. SHORTLIFFE, Professor and Chair, Columbia Presbyterian Medical Center, Columbia University
HUGO F. SONNENSCHEIN, Charles L. Hutchinson Distinguished Service Professor, The University of Chicago
PAUL E. TORGERSEN, John W. Hancock, Jr. Chair and President Emeritus, Virginia Polytechnic Institute and State University
IRVING L. WEISSMAN, Karel and Avice Beekhuis Professor of Cancer Biology, Stanford University, School of Medicine
SHEILA WIDNALL, Abby Rockefeller Mauze Professor of Aeronautics, Massachusetts Institute of Technology
WILLIAM A. WULF (Ex-Officio), President, National Academy of Engineering

RICHARD E. BISSELL, Executive Director
DEBORAH D. STINE, Associate Director
MARION E. RAMSEY, Administrative Associate

Preface

In 1995, the National Academy of Sciences, National Academy of Engineering, Institute of Medicine, and National Research Council issued a report entitled *Allocating Federal Funds for Science and Technology*, which recommended tracking federal investments in the creation of new knowledge and technologies—what the report referred to as the federal science and technology budget (FS&T). The Academies' Committee on Science, Engineering, and Public Policy (COSEPUP) has issued four reports in an annual series tracking the President's proposed FS&T budget and commenting on its potential impacts on our ability to meet national goals and sustain global leadership in science and engineering. This report is the fifth in this series and is designed to follow up and draw on earlier reports from the Academies on federal goals and funding for science and technology, as well as comment on the current fiscal year budget proposal. It is authored by the Committee on the FY 2003 Federal Science and Technology Budget under the aegis of COSEPUP. It is intended to inform Congressional Appropriators, the Administration, and other stakeholders as the FY 2003 appropriations process is concluded and proposals are developed for FY 2004.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report: Christopher T. Hill, George Mason University; Kei Koizumi, American Association for the Advancement of Science; Venkatesh Narayanamurti, Harvard University; Gilbert Omenn, University of Michigan; Paul M. Romer, Stanford University; Daniel R. Sarewitz, Columbia University; and Gabor Somorjai, University of California, Berkeley.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by Floyd E. Bloom, Scripps Research Institute. Appointed by the National Research Council, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

The production of this report was the result of hard work in a short time period by the study committee. The Committee was assisted in this study by Peter Henderson, study director, and Elizabeth Briggs, administrative assistant.

James Duderstadt, *Chair*
Committee on the FY 2003 Federal Science and Technology Budget

Contents

Figures and Tables

FIGURES

TABLES

Executive Summary

ALLOCATING FEDERAL FUNDS FOR SCIENCE AND TECHNOLOGY

The United States benefits from a world-class science and engineering enterprise. This tremendously productive system has contributed importantly over the last half-century to economic growth, innovation, and advancing national goals in space exploration, defense, energy security, health, and the environment. Federal investment in science and technology has played a critical role in sustaining this system.

In *Science, Technology, and the Federal Government: National Goals for a New Era,* the National Academies' Committee on Science, Engineering, and Public Policy recommended two goals to guide federal investment in science and technology:

> First, the United States should be among the world leaders in all major areas of science. Achieving this goal would allow this nation quickly to apply and extend advances in science wherever they occur.
>
> Second, the United States should maintain clear leadership in some areas of science. The decision to select a field for leadership would be based on national objectives and other criteria external to the field of research.[1]

These goals provide the foundation upon which federal science and technology (FS&T) budgetary policy should be built and analyzed.

In *Allocating Federal Funds for Science and Technology*, the National Research Council recommended that the Executive Office of the President and Congress develop a more coherent budget process for determining the federal investment in programs that create new knowledge and technologies to meet these goals. The report recommended that the President should present annually a Federal Science and Technology (FS&T) Budget proposal that addresses both current national priorities and the investments necessary to sustain a world-class science and technology enterprise.[2]

The U.S. Office of Management and Budget (OMB) has developed an FS&T Budget that is consistent with the NRC's concept and an effective approach for conceptualizing and tabulating federal investments in science and

[1] National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Science, Technology, and the Federal Government: National Goals for a New Era*, Washington, D.C.: National Academy Press, 1993.

[2] National Research Council, *Allocating Federal Funds for Science and Technology*, Washington, D.C.: National Academy Press, 1995, p. v.

technology across the federal government. The institutionalization of the FS&T budget as a concept and a process is critically important to the analysis of short- and long-term investments in science and technology and, as discussed in our report on the President's FY 2002 FS&T proposal, the National Research Council endorses the approach to tabulating FS&T that OMB has developed. The list of programs in OMB's tabulation of the FS&T budget can be found in Table 1.[3]

THE PRESIDENT'S FY 2003 FEDERAL SCIENCE AND TECHNOLOGY BUDGET

For fiscal year (FY) 2003, the Administration's budget proposal would increase the FS&T spending by 7.0 percent, from $52.3 billion to $56.0 billion, in constant FY 2002 dollars. The Administration would fund substantial increases for its high-priority initiatives, such as completing the doubling the budget of the National Institutes of Health (NIH). Under the Administration's proposal, 94 percent of the increase in FS&T spending, or $3.4 billion in constant FY 2002 dollars, would go to NIH. The administration would also focus a large part of its proposed increase on research that would help counter terrorist threats. Under its proposal, the Administration targets about $1.7 billion, or about 40 percent of the proposed NIH increase, to research at the NIH focusing on countering bioterrorism.

Despite the large overall increase proposed for FS&T, there are two important concerns with the Administration's budget proposal that merit further consideration.

First, the nation should identify national goals and agency missions and set funding priorities in line with those goals and missions, and the Administration has done so. However, the nation should also ensure the adequacy of funding across the science and engineering enterprise—as recommended by the Academies in *Science, Technology, and the Federal Government: National Goals for a New Era*—to facilitate world-class science and engineering across fields and to ensure preeminence in key disciplines. It is critically important to sustain world-class science and technology across fields so that we can generate and benefit from advances wherever they come from and meet challenges whenever they rise. Although we know that breakthroughs will occur as a result of our investment in research generally, we do not know which specific fields they will emerge from. For example, the results of research in quantum physics in the first half of the twentieth century later led to such diverse developments as transistors, with an array of electronic applications, and magnetic resonance imaging, with important medical applications, in the second half of the century.

Although the Administration has established FS&T priorities for FY 2003, it has not addressed the issue of adequacy of funding across the FS&T portfolio. In constant dollars, the NIH budget would increase by 14.6 percent, or $3.4 billion, while all of the rest of the FS&T budget would increase by 0.8 percent, or just $221 million. Indeed, FS&T funding for most departments and agencies would decrease in constant dollars under the President's budget proposal.

Reductions in funding for certain agencies, such as the Departments of Energy and Defense, would negatively impact specific fields in the physical sciences and engineering that were already cut substantially in the 1990s. These trends affect the amount of research that can be conducted in the short run because of the reduced funding available. They therefore affect our ability to generate and capitalize on breakthroughs that might come from such fields. They also affect our nation's ability to maintain world-class scientific research across fields in the long run, because research and graduate education are closely linked and reductions in research funding have led to decreased enrollment of graduate students. FS&T investments sustain key university programs that not only contribute to the nation's research capability but also produce the scientists and engineers necessary to maintain the nation's scientific and technological strength, so key to economic competitiveness and national security.

In addition to establishing current funding priorities, Congress and the President should consider the health of science and engineering across fields in its budget allocations. Funding for science and technology is an invest-

[3]Much of FS&T, which totaled $52.3 billion in FY 2002, is counted in the R&D budget, which totaled $103.2 billion in FY 2002. Unlike the R&D budget, FS&T is comprised of identifiable line items in the budget and includes all costs, including staff salaries, associated with those programs. FS&T focuses more narrowly on research and also includes key science and engineering education programs at the National Science Foundation.

ment for the long term. This investment should ensure U.S. capacity across fields that allows us to capitalize on opportunities presented by research breakthroughs and also to respond to important challenges. International benchmarking—which examines funding and productivity for a field across countries—can provide a guide for evaluating whether the United States is making the kinds and levels of investments needed by field to sustain this capacity and our place among the world's leaders in science and engineering.

Second, the Administration proposes very little new funding for research carried out by agencies other than NIH that would also contribute to countering terrorism. In *Making the Nation Safer*, a report that was not yet available when the Administration prepared its budget proposal, the National Research Council outlines the potential impact of science and technology research in seven cross-cutting areas—systems analysis and modeling, integrated data management, sensors and sensor networks, robotic technologies, SCADA systems, biometrics, and human factors—on counterterrorism efforts. Importantly, the report argues "the realization of this potential will depend on a program of directed basic and applied research and *will require an expansion and coordination of existing S&T programs and funding* if the government's work is to produce effective tools for countering terrorism and ensuring homeland security." (emphasis added)[4] Moreover, the report notes, in order to realize the potential a "balance of investments is critical, across different time horizons as well as across numerous disciplines."[5] Although research on countering bioterrorism conducted by NIH will be productive, research carried out by other agencies, such as the Department of Defense, and drawing on a range of fields, can also contribute substantially to efforts to counter terrorist threats against the United States. The Administration and Congress should revisit the FS&T budget proposals in light of the recommendations of *Making the Nation Safer*.

As shown in Figure 5 on page 20 of this report and Table 6 on page 31, Congress matched, and slightly exceeded, the Administration's recommended increase for NIH in FY 2002. It also provided funding for science and technology that exceeded the Administration's request for almost every other agency. For example, the Administration proposed an increase in constant dollars of 0.8 percent for the National Science Foundation, but Congress later enacted an increase of 8.1 percent for NSF as a means for increasing funding for a broad range of science and engineering fields. Congress should again consider adequacy of funding for research across fields as it finalizes appropriations for FY 2003.

ENSURING PERFORMANCE AND LEADERSHIP

The Administration is taking important steps to ensure that federal resources for science and technology are being spent in a productive manner. First, all of the resources available for science and engineering research must be utilized to focus on the important national goals we face, including not only specific near-term objectives but also the nation's longer-term scientific and technological strength. The Administration has correctly identified the Congressional practice of earmarking funds for research at specific institutions as one that must be curtailed. Reducing earmarks for research is the responsibility of the research community and Congress. University leaders and individual researchers should follow principles such as those endorsed by the Association of American Universities.[6]

Second, federal funds invested in science and engineering programs must result in relevant, high-quality research. In developing and implementing its Research and Development Investment Criteria, OMB should seek to verify that the science and technology programs it funds are directly related to the advancement of important national goals and produce high-quality research. While collecting data from R&D program managers under GPRA and R&D evaluation processes is one method for gathering information to assess the performance of R&D programs, other means are also available. The Administration should consider methods such as external program reviews for examining the efforts of specific programs. In assessing the performance of federal programs, the

[4] *Ibid*., pp. 332-334
[5] *Ibid*.
[6] Association of American Universities, "AAU Research Policy Issues: Strengthening the University-Federal Government Research Partnership," March 2002, http://www.aau.edu/sheets/RschPolicy.html

Administration should also examine whether federal investments keep our nation among the world leaders in science and engineering research across fields. International benchmarking provides one method for analyzing the status of U.S. science in particular fields.[7] The Administration should consider mechanisms such as this as it moves forward with analyses of the outcomes of federal science and technology programs.

As the Administration extends the application of applied R&D criteria throughout the government for use in the development of the FY 2004 budget, it should be mindful of the difference between a focus on "performance" and a focus on "leadership." Performance measures that focus too heavily on near-term results may provide strong incentives to focus on conservative goals. Performance measures that focus on results without assessing whether a program has adequate funding may penalize a program by decreasing its funding, when, in fact, the program requires increased funding. A focus on leadership, by contrast, would examine adequacy of funding, infrastructure, and human resources and whether programs promote risky research on the frontiers of knowledge. The goal of federal funding for research is to maintain a science and engineering enterprise that is world-class across fields and preeminent in fields relevant to national priorities.

[7] National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Experiments in International Benchmarking of U.S. Research Fields*, Washington, D.C.: National Academy Press, 2000.

Observations on the President's FY 2003 Federal Science and Technology Budget

INTRODUCTION

In 1995, the National Research Council, in *Allocating Federal Funds for Science and Technology*, recommended that the Executive Office of the President and Congressional appropriators carefully examine the annual proposed federal investment across agencies in programs that create new knowledge or enabling technologies to ensure that, collectively, these investments address national goals and sustain the overall science and engineering enterprise. To facilitate this review and analysis, the NRC recommended the annual preparation of the Federal Science and Technology (FS&T) Budget. This report, fifth in a series, provides observations on national goals for science and technology and on the President's proposed fiscal year (FY) 2003 FS&T budget in relation to those goals.

The first section of the report outlines the development during the 1990s of national goals for science and technology and of a means for tabulating the FS&T budget. The second section summarizes the President's FS&T budget proposal for FY 2003. It also provides a review of an NRC report on science and technology for countering terrorism, published since the President's budget release, that offers important recommendations for long-term funding of S&T programs as they relate to counterterrorism activities. The third section of the report provides observations on the President's budget, which proposes a very large increase for biomedical research and, in the aggregate, only a very small increase for the rest of the FS&T programs. If Congress were to enact the President's budget request, the increase of $3.4 billion in constant FY 2002 dollars for the National Institutes of Health (NIH) would account for 94 percent of the overall increase in FS&T funding.[1] This section also outlines a process for considering funding for both priority-driven research and discovery-oriented research that will sustain S&T across all fields for the long term. The fourth section provides recommendations for ensuring that federally funded S&T programs provide high-quality research outcomes that are relevant to agency missions and provide the U.S. with global leadership in science and engineering.

[1] Deflators used to convert current dollar amounts to constant FY 2002 dollars are derived from the GDP (chained) price index listed in Table 10.1, Gross Domestic Product and Deflators Used in the Historical Tables, 1940–2007, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. Government Printing Office, 2002.

NATIONAL GOALS FOR SCIENCE AND TECHNOLOGY

The nation has benefited significantly from an enduring federal system for funding and sustaining world-class science and engineering. This tremendously productive system has contributed importantly over the last half-century to economic growth, innovation, and advancing national goals in space exploration, defense, energy security, health, and the environment.

In the 1990s, this system faced important challenges. Changes brought about by economic globalization, the end of the Cold War, the rapid growth of information technology, and emerging changes in the way scientists and engineers carry out their work suggested new priorities for federal funding in science and technology. Policy makers began to discuss how best to allocate funding across science and technology programs in light of these shifting priorities, particularly because short-term pressure for reining in government spending meant that trade-offs between programs would be necessary as funding was reallocated. The large federal budget deficits of the early 1990s led to very tight limits on FS&T increases across agencies, including NIH.

In the mid-1990s, the National Academies addressed the need for establishing explicit national goals for science and technology in this new era and the means for allocating resources to meet those goals through two reports, *Science, Technology, and the Federal Government: National Goals for a New Era* (1993) and *Allocating Federal Funds for Science and Technology* (1995). These reports and their recommendations are described below.

Leadership in Science and Technology

In *Science, Technology, and the Federal Government: National Goals for a New Era*, published in 1993, the Academies' Committee on Science, Engineering, and Public Policy (COSEPUP) recommended two national goals for science that could guide future federal investment in science and technology:

> First, the United States should be among the world leaders in all major areas of science. Achieving this goal would allow this nation quickly to apply and extend advances in science wherever they occur.
>
> Second, the United States should maintain clear leadership in some areas of science. The decision to select a field for leadership would be based on national objectives and other criteria external to the field of research.[2]

The National Science Board, in a recent review of the process for allocating resources for federally funded research entitled *Federal Research Resources: A Process for Setting Priorities*, echoed these goals by recommending that this process "place a priority on investments in areas that advance important national goals, identify areas ready to benefit from greater investment, address long-term needs and opportunities for federal missions and responsibilities, and ensure world-class fundamental science and engineering capabilities across the frontiers of knowledge."[3]

Both *National Goals* and *Federal Research Resources* recommended assessing the performance of U.S. research in a major field compared with research undertaken by scientists in other countries, a task known as international benchmarking. Such assessments would provide the information needed to determine whether the U.S. investment in a field is adequate for ensuring that the United States is at least world-class in that field. Societal concerns and needs, as determined through priorities established by the political process, would determine whether U.S. investment should be increased above this world-class level to attain clear leadership in a field.

Allocating Federal Funds for Science and Technology

The *National Goals* report concluded also that the implementation of its goals for science required a more coherent federal budgetary process. In 1994, the U.S. Senate Committee on Appropriations asked the National Academies to issue a report that outlined what this new process might look like. Specifically, the Committee asked

---

[2]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Science, Technology, and the Federal Government: National Goals for a New Era*, Washington, D.C.: National Academy Press, 1993.

[3]National Science Board, *Federal Research Resources: A Process for Setting Priorities* (NSB 01-156), Arlington, VA: National Science Foundation, 2001, p. 4.

the Academies to address "the criteria that should be used in judging the appropriate allocation of funds to research and development activities, the appropriate balance among different types of institutions that conduct such research, and the means for assuring continued objectivity in the allocation process."[4]

In *Allocating Federal Funds for Science and Technology*, a report issued in 1995, the National Research Council responded to the Congressional charge by outlining a process for proposing and enacting federal investments. First, and foremost, it urged that this process focus on federal investments in programs that create new knowledge and enabling technologies—what the report called the federal science and technology (FS&T) budget. Second, the report advised the Executive Office of the President to annually present a comprehensive FS&T budget proposal that addresses *both* current national priorities and the investments necessary to sustain a world-class science and technology enterprise. This FS&T budget should be the result of a process by which the U.S. Office of Management and Budget (OMB) would establish cross-cutting national priorities for science and technology, provide agencies with clear guidance on these priorities, and review agency budget proposals to ensure that they support the priorities.[5]

OMB has accepted the FS&T budget concept and refined it over the last five budget cycles. OMB's first approach to tabulating FS&T was presented in the President's FY 1999 budget cycle as the "Research Fund for America," which focused on civilian research priorities. OMB evolved and refined this tabulation over the next two cycles as the "Twenty-First Century Research Fund," which also included basic and applied defense research. OMB then carried this approach forward with the FY 2002 budget proposal, making further refinements and renaming it the "Federal Science and Technology Budget" to bring it explicitly in line with the Academies' FS&T concept.

The institutionalization of the FS&T budget as a concept and a process is critically important to the analysis of short- and long-term investments in science and technology, and, as discussed in our report on the President's FY 2002 FS&T proposal, the National Academies endorse the approach to tabulating FS&T that OMB has developed for the following reasons: OMB's FS&T budget tabulation focuses on the largest S&T programs. It includes all costs associated with those programs, including staff salaries. It also includes key science and engineering education programs at the National Science Foundation that are not considered research and development (R&D) but are critical investments in science and technology. Unlike the R&D budget, it is comprised of identifiable line items in the budget, permitting easy tracking through the Congressional Appropriations process. The list of programs in OMB's tabulation of the FS&T budget can be found in Tables 1 and 2.[6]

THE PRESIDENT'S FY 2003 FEDERAL SCIENCE AND TECHNOLOGY BUDGET

The Administration based its overall budget proposal for FY 2003 on four overarching programmatic, fiscal, and managerial priorities: funding the war against terrorism at home and overseas; stimulating the economy to foster job creation; providing increases for high-priority initiatives while moderating growth in the rest of government; and reforming the budget to focus on results instead of dollars spent. The Administration has proposed a FY 2003 FS&T budget that purports to be in line with these overarching guidelines. It would:

- provide incremental funding for research at the NIH that focuses on countering bioterrorism.
- increase the R&D budget by 6.7 percent, from $103 billion to $110 billion, in constant FY 2002 dollars, and the FS&T budget by 7.0 percent, from $52 billion to $56 billion, in constant FY 2002 dollars.
- fund substantial increases for its high-priority initiatives, such as doubling the NIH budget, while "moderating growth" for the rest of the FS&T budget. The FS&T budget, with funding for NIH excluded, would grow less than 1 percent from FY 2002 to FY 2003.

---

[4]National Research Council, *Allocating Federal Funds for Science and Technology*, Washington, D.C.: National Academy Press, 1995, p. v.
[5]*Ibid.*
[6]About 80 percent of FS&T, which totaled $52.3 billion in FY 2002, is counted in the R&D budget, which totaled $103.2 billion in FY 2002. Unlike the R&D budget, FS&T is comprised of identifiable line items in the budget and includes all costs, including staff salaries, associated with those programs. It also includes non-R&D programs such as science and engineering education programs at NSF.

- implement "R&D Investment Criteria" developed by OMB to examine R&D programs and expenditures through the lens of performance.[7]

There are several concerns with the Administration's budget proposal that merit further consideration. First, as shown below, the Administration proposes very little new funding for research carried out by agencies other than NIH, such as the Department of Defense, that would also contribute to countering terrorism. Second, it would reduce FS&T funding in constant dollars for most departments and agencies, such as the Departments of Energy and Defense, that support physical science and engineering research and contribute to important agency missions and national goals. Third, mechanisms for reviewing FS&T programs and expenditures should examine not just short-term program performance but also whether federal spending leads to long-term global leadership in science.

The President's S&T Priorities

The Administration has identified biomedical research as its top S&T research priority and proposes a substantial increase in this area in absolute and percentage terms. It has proposed substantial percentage increases in funding for other areas as well, although in absolute terms the increases are small, especially relative to the proposed increase for NIH. The President's budget proposes increases in FS&T for the following programs and initiatives—analysis is in constant dollars as shown in Table 2 (for current dollar amounts and calculations, see Table 1):

- **Biomedical research**: The Administration's proposed budget for FY 2003 would increase the budget of NIH by $3.4 billion, or 14.6 percent, to $26.8 billion in FY 2002 constant dollars. About $1.7 billion, 40 percent, of the proposed NIH increase, would be targeted to activities, mainly in the National Institute of Allergy and Infectious Diseases (NIAID), related to countering bioterrorism. Another 20 percent of the increase would be made available to the National Cancer Institute to increase cancer research, seen by the Administration as a primary vehicle for supporting "research on diseases affecting the lives of all Americans." The remaining 23 institutes at NIH would share the rest of the proposed increase for the agency. The Administration also proposes an increase of $29 million, or 7.7 percent, in FS&T for clinical, epidemiological, and behavioral research in the Department of Veterans Affairs.
- **Space Science**: Space science at the National Aeronautics and Space Administration would receive an increase of $333 million, or 11 percent, in constant dollars under the President's budget proposal. The space science budget would fund a revamped New Frontiers program "of competitively selected planetary missions focused on understanding the origins and existence of life beyond earth." The President's budget proposal also targets an increase of $250 million, or 9.8 percent, for NASA's aerospace technology program.
- **Nanotechnology**: The Administration supports the potential for scientific advancement through nanoscale research by recommending an increase of $88 million, or 15.2 percent, in constant dollars for the National Nanotechnology Initiative. This program, led by the National Science Foundation (NSF), focuses on the manipulation of matter at the atomic and molecular levels that could lead to new breakthroughs in materials, electronics, information technology, and biotechnology. Nine agencies participate in this initiative, with most of the funding shared by NSF and the Departments of Defense and Energy.
- **Climate Change Research**: The Administration's budget proposes an increase of $53 million, or 3.2 percent, in constant dollars in combined funding for the U.S. Global Change Research Program and a new Climate Change Research Initiative (CCRI). The total FY 2003 budget for these programs, which would

[7]Details of the Administration's Federal Science and Technology Budget proposal can be found in Chapter 8, "Research and Development," in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Analytical Perspectives*, Washington, D.C.: U.S. Government Printing Office, 2002. For a comprehensive analysis of the Administration's proposed R&D spending see also Intersociety Working Group, *AAAS Report XXVII: Research & Development 2003*, Washington, D.C.: American Association for the Advancement of Science, 2002.

be $1,723 million in constant FY 2002 dollars, would still be below the FY 2000 level for these programs. NASA, responsible for the satellites that are key to research in this area, would receive almost two-thirds of the funding for climate change research. The $40 million proposed for the new CCRI, led by the National Oceanic and Atmospheric Administration (NOAA) and NSF, would be targeted to addressing key gaps in knowledge identified in the National Academies report, *Climate Change Science: An Analysis of Some Key Questions*.[8]

- **Environmental Protection**: The President's budget also proposes an additional $33 million, or 4.4 percent, in constant dollars for the Environmental Protection Agency (EPA). EPA's priority FS&T programs for FY 2003 will examine issues related to assessing the cumulative risks of complex pollutant mixtures and will provide scientific support to its highest-priority pending regulatory issues.
- **Education Research and Innovation**: Under the President's proposal, FS&T in the Department of Education would increase by $46 million, or 12.3 percent, in constant dollars from FY 2002 to FY 2003. This increase would be targeted entirely at programs in the Office of Educational Research and Improvement (OERI) that would increase research on effective preschool curricula and on how children learn to read. It would also focus on identifying strategies to enhance the use of research findings by teachers, school administrators, and policy makers. This effort could be productive, particularly if the Department of Education collaborated closely with the Math and Science Partnership Program, another Presidential priority, administered by NSF. Implementing new knowledge about how people learn in the classroom is critical for reading, science, and mathematics, and programs run by the Department of Education and NSF should both benefit from this work.

These areas, and perhaps others, hold significant promise for addressing short-term policy issues or long-term research objectives. The National Research Council has described research needs in several of these areas, for example, nanotechnology and climate change, both of which are identified and funded as cross-cutting priorities by the Administration, and astronomical research, a field funded in part by the NASA Space Science program.[9] Still, the Administration has assigned biomedical research its highest priority among all of these areas as measured by proposed increases in absolute dollars. Although large percentage increases are slated for each of these areas, the absolute increase of $3.4 billion for NIH dwarfs the dollar increases of all other areas combined that are slated for growth.[10]

The President's Proposal for FS&T in Other Agencies

Although the Administration proposes substantial increases for its high-priority initiatives, it would moderate growth or cut budgets in other areas of science and technology. This can be seen both in the budget proposals for individual agencies and in the aggregate by contrasting the proposed increase for NIH with the proposed increase in total FS&T for other agencies.

NSF, the one federal agency charged with funding research across the science and engineering enterprise, would receive only a very modest increase in funding under the President's proposal. The NSF budget would increase by $152 million, or 3.2 percent, in constant dollars, to almost $5 billion under the proposal, with the proposed budget for NSF's Research and Related Activities (R&RA) Account increasing at about the same rate.

---

[8]National Research Council, *Climate Change Science: An Analysis of Some Key Questions*, Washington, D.C.: National Academy Press, 2001.

[9]National Research Council, *Small Wonders, Endless Frontiers: Review of the National Nanotechnology Initiative*, Washington, D.C.: National Academy Press, 2002. National Research Council, *Climate Change Science: An Analysis of Some Key Questions*, Washington, D.C.: National Academy Press, 2001. National Research Council, *Federal Funding of Astronomical Research*, Washington, D.C.: National Academy Press, 2000.

[10]The Administration's out-year projections would provide NIH with smaller increases that may result in critical grant management issues for the agency. However, NIH would still receive the largest increase in R&D spending from FY 2002 to FY 2007 under the Administration's proposal. Intersociety Working Group, *AAAS Report XXVII: Research & Development FY 2003*, Washington, D.C.: AAAS, 2002, pp. 25-26 and 31-33 and Table I-11.

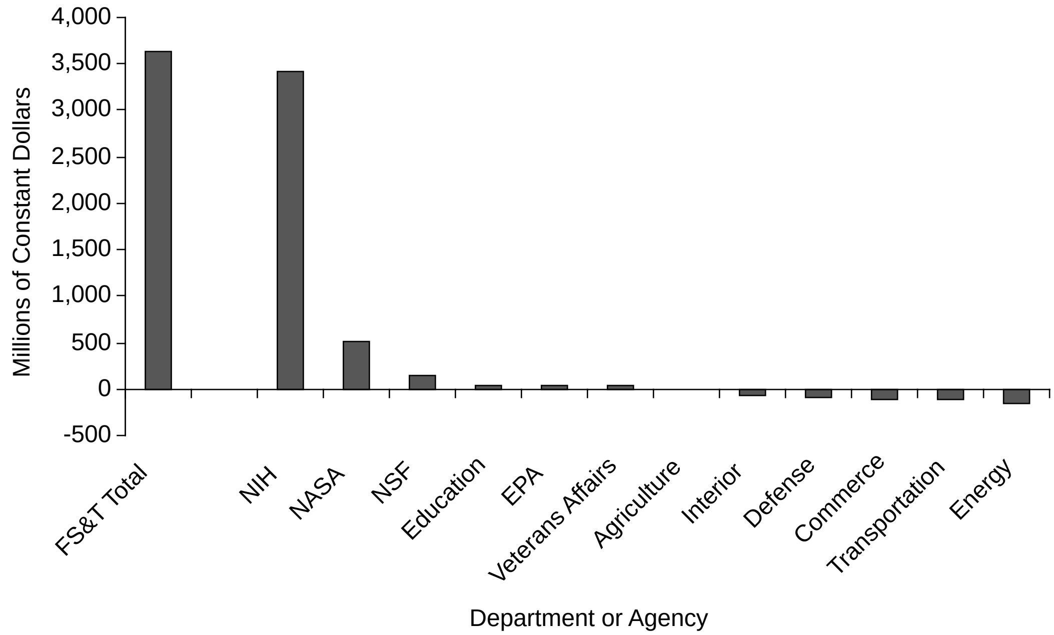

FIGURE 1 Proposed Change in FS&T Spending, by Department or Agency, FY 2002–FY 2003 (millions of constant FY 2002 dollars). Source: *Budget of the United States Government, Fiscal Year 2003*.

However, the proposed NSF increase includes funding for three programs currently at other agencies that the Administration proposes to transfer to NSF. The funding for these programs inflates the NSF increase relative to the FY 2002 budget, which did not include these programs. If the total funding of $75 million (in constant FY 2002 dollars) for these programs—NOAA's National Sea Grant Program, the U.S. Geological Survey (USGS) Hydrology of Toxic Substances program, and EPA's Environmental Education program—were subtracted from the proposed NSF budget, the agency's increase would be just $77 million, or 1.6 percent, in constant dollars.

Funding for Networking and Information Technology R&D, a cross-cutting initiative carried out by seven federal agencies, would be relatively flat, increasing by $13 million, or 0.7 percent, in constant FY 2002 dollars, to $1.86 billion. The Administration designated this R&D initiative a priority area for FY 2003, and, as with nanotechnology and climate change research, the National Academies has described the need for expanding research in information technology to meet societal goals, including research funded by the federal government.[11] However, the Administration has proposed only a very small increase in funding in real terms.

The Administration's proposal would reduce the budgets of the remaining S&T agencies in constant dollars. The FS&T budget for the Department of Agriculture would be relatively flat, declining 0.6 percent in constant dollars. The FS&T budgets for the Departments of Defense, Energy, and Transportation would decrease by 1.9, 3.2, and 17.3 percent, respectively. The Defense basic research budget would be flat, increasing by 0.4 percent in constant dollars, whereas Defense applied research would decrease by 2.8 percent. DOE's Science Program would decrease by 0.4 percent in constant dollars. The budget for the USGS would decrease by 6.5 percent, and

[11]National Research Council, *Making IT Better: Expanding Information Technology Research to Meet Society's Needs*, Washington, D.C.: National Academy Press, 2000.

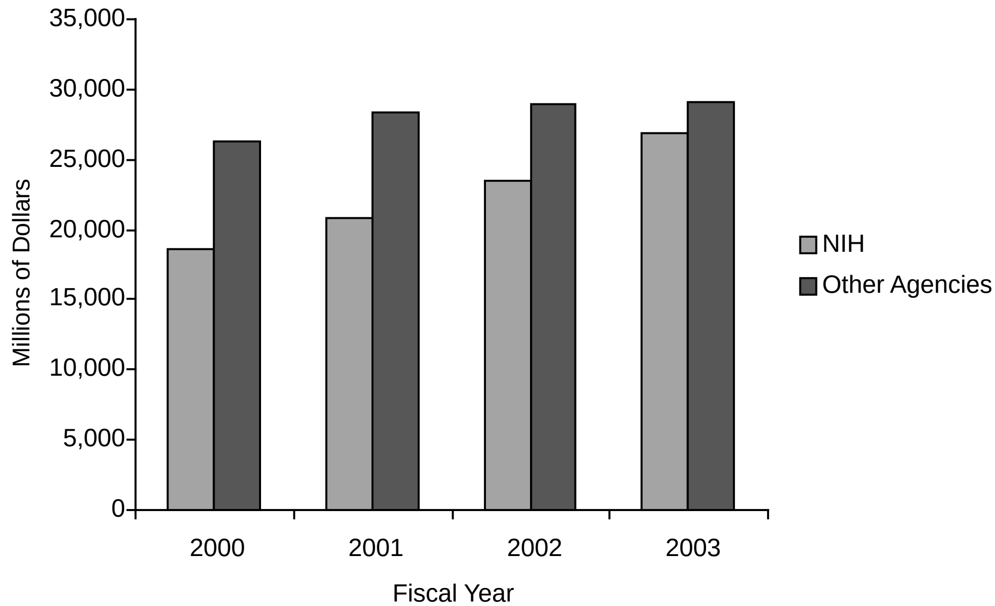

FIGURE 2 Federal Funding for FS&T at NIH and at All Other Agencies Combined, FY 2000–FY 2003 (millions of constant FY 2002 dollars). Source: *Budget of the United States Government, Fiscal Year 2003.*

those for the National Institute of Standards and Technology (NIST) and NOAA in the Department of Commerce would decrease by 5.5 and 19.4 percent, respectively.

In sum, the President's priorities for science and technology in FY 2003 focus primarily on biomedical research as the Administration seeks to fulfill its campaign promise to complete the doubling of the budget for the National Institutes of Health (NIH). Whereas the Administration proposes a 14.6 percent increase for NIH, the rest of FS&T budget excluding NIH would be relatively flat, increasing less than 1 percent in constant dollars. In constant dollars, as seen in Figure 1, the NIH budget would increase by $3.4 billion, while all of the rest of the FS&T budget would increase by just $221 million, taking both proposed increases and decreases into account. As a result, the increase in the NIH budget represents 94 percent of the proposed increase in FS&T.

The NIH budget now dominates F&ST spending. As shown in Figure 2, were the Administration's proposals enacted, the NIH budget as a percentage of the FS&T budget would increase to 48 percent, or almost half, up from about 40 percent in FY 2000. In 2001, NIH provided 60 percent of federal funding for university-based research. This percentage is likely to increase given the disparate trends in funding across fields.[12]

Science and Technology for Countering Terrorism

Since the tragic events of September 11, 2001, the science and engineering community has sought to contribute its technological expertise to near- and long-term solutions to problems associated with countering terrorism and

[12]National Science Foundation/Division of Science Resources Studies, *Federal Funds for Research and Development: Fiscal Years 1999, 2000, 2001*, Volume 49 (NSF 01-328), Arlington, Va.: National Science Foundation, 2001, Tables C-29 and C-40.

terrorist events, clearly a high national priority. The Administration recently observed that the immediate problem of homeland security is not one of fundamental science, but rather the implementation of currently available technology.[13] In the very near term, this is very certainly true. The Administration has, however, rightly proposed a substantial increase in funding for basic research at NIH related to combating bioterrorism. Indeed, the Administration's budget proposal targets 40 percent of the NIH increase and almost all of the new antiterrorism S&T funding to programs related to combating bio-terrorism. The NIAID has a well-defined bioterrorism program that should produce important research for the nation. The increased funding in this area would be welcome as an important start in funding one piece of the science and technology research that contributes to countering terrorist threats.

Soon after the events of last September, the National Academies convened a committee cochaired by Lewis Branscomb and Richard Klausner to study the potential for science and technology to contribute to countering terrorism over the long run. This committee's final report, entitled *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*, was released in June 2002 and so was not available to the Administration when it formulated its budget proposal for FY 2003. We strongly recommend that Congress and the Administration consider the findings and recommendations of this report as they finalize appropriations for FY 2003 and formulate budget proposals for FY 2004 and beyond.

In brief, this report makes a strong case for a long-term S&T agenda that includes investments and research across all fields of science and engineering.[14] While it is true that immediate technological response to the reduction of homeland vulnerabilities requires the use or adaptation of technology that is "on the shelf," presently available technologies and present-day knowledge are far short of the potential contribution of science and technology to homeland security. Although it is also true that a substantial national investment in funding for research on issues related to bioterrorism is likely to produce substantial returns, research in a range of fields across both the biological and physical sciences can contribute to the national effort to counter terrorism in important ways.

Research on sensors and sensor-nets, for example, is still at an early stage. It is possible to imagine a network of biosensors in a subway system or in a metropolitan area that could give warning of a bioterrorist event. There has been much discussion of this capability, but bringing such systems about will require fundamental work in chemistry and biology, the development of sensors, perfection of technology that allows wireless communication of sensors with receiving stations that, in turn, have links to supercomputers with appropriate software for analysis and visualization, and links to local, state, and federal authorities. Making this kind of system effective requires substantial work that can only be categorized as FS&T.

Accordingly, *Making the Nation Safer* outlines the potential impact of science and technology research in seven cross-cutting areas—systems analysis and modeling, integrated data management, sensors and sensor networks, robotic technologies, SCADA systems, biometrics, and human factors—on counterterrorism efforts. Importantly, the report goes on to argue "the realization of this potential will depend on a program of directed basic and applied research and *will require an expansion and coordination of existing S&T programs and funding* if the government's work is to produce effective tools for countering terrorism and ensuring homeland security." (emphasis added)[15] Further, the report notes that, in addition to the current level of effort being "too small," a "balance of investments is critical, across different time horizons as well as across numerous disciplines. The government's underinvestment in the physical sciences and engineering has been documented in a variety of reports…"[16]

---

[13]See John Marburger, "Science and Technology in a Vulnerable World: Rethinking our Roles," Keynote Address to the 27th Annual AAAS Colloquium on Science and Technology Policy, April 11, 2002. Full text of speech can be found on-line at http://www.ostp.gov/html/02_4_15.html.

[14]National Research Council, *Making the Nation Safer: The Role of Science and Technology in Countering Terrorism*, Washington, D.C.: National Academy Press, 2002.

[15]*Ibid*., pp. 332-334

[16]*Ibid*.

Again, Congress and the Administration should consider the findings and recommendations of *Making the Nation Safer* as they finalize appropriations for FY 2003 and formulate budget proposals for FY 2004 and beyond. In light of these recommendations, Congress and the Administration should pay particularly close attention to appropriations for basic and applied research carried out by NSF, DOE, DOD, and NIST as they relate to advancing technology for countering terrorism. Congress may also wish to consider the role and funding of social and behavioral research in understanding both the causes of terrorism and the behavior of terrorists and terrorist groups as steps toward preventing or discouraging terrorism. While research on countering bioterrorism conducted by NIH will be productive, research carried out by these other agencies and across a range of disciplines can also contribute substantially to efforts to counter terrorist threats against the United States. In this vein, Congress should also give careful consideration to the role and funding of science and technology in the proposed Department of Homeland Security.

OBSERVATIONS ON THE PRESIDENT'S FS&T BUDGET PROPOSAL

The nation should continue to invest in science and technology at a level and in a pattern that would allow science and engineering to contribute to agency missions, address important national goals across agencies, and sustain our global competitiveness and leadership in science now and in the future. Because resources are limited, the nation should identify national goals and agency missions and set funding priorities in line with those goals and missions. The nation should also ensure the adequacy of funding across the science and engineering enterprise—as recommended by the Academies in *Science, Technology, and the Federal Government: National Goals for a New Era*—to facilitate world-class science and engineering across fields and to ensure preeminence in key disciplines.[17]

Priority-Driven Research

Research priorities must be determined by national goals and agency missions. As the *National Goals* report made clear, the decision to select a field for clear global leadership should be based on national objectives and other criteria external to the field of research. Clearly, prior Administrations have set a variety of priorities over the last 50 years—space exploration, nuclear weapon development and control, energy security, biomedical research—that have affected the ebb and flow of funding to specific science and engineering fields. Many of these priorities resulted in significant, though sometimes temporary, funding increases for fields in the physical sciences and engineering that have experienced reduced funding as priorities have changed in the last decade. The rise of and subsequent end to the Apollo program provides a case in point. Other policy priorities, such as improving the nation's health, led to significant and sustained long-term growth in biomedical research funding. (From FY 1976 to FY 2002, the R&D budget for NIH increased 275 percent, an annualized rate of growth of 5.2 percent, in constant dollars, while the rest of nondefense R&D [that is, excluding NIH] grew 15 percent, an annualized rate of growth of just 0.5 percent, in constant dollars.)[18] Many of these strategic research efforts, in such diverse fields as aeronautical engineering, AIDS research, and agriculture, have been highly successful.

The current Administration has likewise identified areas where policy-driven research must be undertaken to meet current national needs. Increases in federal funding are warranted to meet real national objectives in cancer

[17]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Science, Technology, and the Federal Government: National Goals for a New Era*, Washington, D.C.: National Academy Press, 1993.

[18]Calculations are based on data in Historical Table 2, Total R&D by Agency, FY 1976-2002 (budget authority in millions of constant FY 2001 dollars), in supplemental material to Intersociety Working Group, *Congressional Action on Research and Development in the FY 2002 Budget*, (Washington, D.C.: AAAS, 2002), http://www.aaas.org/spp/rd/hist02c2.pdf. (Historical trends for FS&T budgets do not exist for years prior to FY 2000, so non-defense R&D has been used as a proxy for it in this illustration. NIH R&D accounts for approximately 96 percent of the NIH FS&T budget, which is the same as total NIH budget.) David Korn, et al, "The NIH Budget in the 'Postdoubling' Era," *Science*, 296: 1401-1402 (2002), discusses historical trends in NIH funding and offers observations on future NIH funding scenarios. This article refers to a historical rate of increase for NIH of 9 percent from 1971 to 1998, unadjusted for inflation.

research, combating bioterrorism, assessing cumulative risks of pollutants, addressing gaps in our knowledge of climate change, and improving the education of preschoolers and early readers. They are also warranted for achieving such goals as reducing dependence on foreign oil through research in renewable or nuclear energy or combating terrorism through research sponsored by the Department of Defense and other agencies.

Because resources are limited, care must also be taken to ensure that federally funded research focused on national needs and goals is the very best research. In the analytical chapter on research and development in its budget proposal this year, the Administration identifies funding for research projects undertaken at "congressional direction" (i.e., through congressional earmarks) and argues forcefully against it. The Administration observes that funding for earmarked projects increasingly results in the reduction of funding available for competitive, merit-reviewed research that could contribute to the achievement of national goals.[19] Congress should take care to minimize earmarks in science and technology, particularly performer-specified earmarks.

The responsibility for minimizing earmarks is also shared by universities and research faculty. In their own defense with regard to earmarking, members of Congress point out that the requests often originate on campuses.[20] In a recent statement, the Association of American Universities (AAU) asserted its support for "the principle of merit review in the allocation of federal funds for scientific research." The AAU statement continued, "We believe that panels of peer scientists are best qualified to judge the merit of proposals for federal funding. This competitive quality review system has a distinguished history that has kept America in the forefront of global scientific discovery.[21] University leaders and research faculty should adhere to these principles in the process of funding scientific research.

Discovery-Oriented Research

Although funding priorities must be driven by policy concerns, questions of adequacy must be addressed by a process that looks to a future that will surely see unforeseen discoveries, unknown goals, and uncertain risks. Here, questions of funding for research must be guided by a strategy that takes advantage of perceived opportunities for discovery and new knowledge but also recognizes that there is tremendous uncertainty about the source of future scientific breakthroughs.[22]

Long-term investments in science and technology should consider perceived opportunities for discovery and enhanced knowledge. Surely, there are important opportunities for advances in knowledge in biomedicine and biotechnology. There are also real opportunities for discoveries that could transform our lives stemming from scientific inquiry at the atomic and molecular level. Nanoscience has the potential for creating breakthroughs in materials, molecular electronics, information technology, and biotechnology, as well as the discovery of new forms and properties of matter. Research in cosmology and astrophysics likewise has the potential for revealing new aspects of the nature of matter that could revolutionize our thinking about a range of scientific fields. Enhancements in information technology through basic and applied research hold great promise for improving the efficiency of American industry. Funding designed to unlock opportunities for our nation in the long run should be cognizant of the new knowledge that could be produced across a range of fields such as these.

Funding for science and technology is a long-term investment in the nation's future rather than simply a current budgetary expenditure. Vannevar Bush articulated this vision in his seminal report, *Science—The Endless*

---

[19]U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Analytical Perspectives*, Washington, D.C.: U.S. Government Printing Office, 2002, p. 162. Although the Committee believes OMB is correct in this assertion, empirical research that substantiates this is warranted.

[20]James D. Savage, *Funding Science in America: Congress, the Universities, and the Politics of the Academic Pork Barrel*, New York: Cambridge University Press, 1999, p. 19.

[21]Association of American Universities, "AAU Research Policy Issues: Strengthening the University-Federal Government Research Partnership," March 2002, http://www.aau.edu/sheets/RschPolicy.html

[22]This view has been articulated by the life sciences community, which has reported "widespread agreement that the federal investment in science must fund research in a broad range of fields." Federation of American Societies for Experimental Biology (FASEB), *Federal Funding for Biomedical and Related Life Sciences Research, FY 2000*, Bethesda, MD: FASEB, 1999, p. 16.

Frontier.[23] Basic research as an investment in the future was an important theme for the Carter Administration.[24] Reports issued in the 1990s from Congress, professional associations, and industrial organizations reaffirmed the importance of investing in research for the long run.[25] In a policy forum published in *Science* in 1996, Michael McGeary and Philip Smith outlined how S&T funding is analogous to financial investing:

> The success of any given research project is uncertain, no matter how carefully it is evaluated. Projects addressing fundamental questions are often the riskiest: success, in the form of useful but unforeseen applications, may not be realized until years later. History also shows that important advances in one field sometimes come from apparently unrelated work in another field. In this situation of unpredictability, diversification is important for maximizing results. If it is not known where the breakthroughs will be made or when advances will occur, then it is prudent to invest in a broad portfolio of activities.[26]

Ralph Gomory made similar observations when he delivered the annual William D. Carey Lecture to the AAS Science and Technology Policy Colloquium in 1995. In his address, he observed that while we can predict that basic research in the aggregate will lead to practical outcomes, we cannot predict what those practical outcomes might be, when they might emerge, and from which fields they might emerge. "We can see when some area of science is useful, but we cannot see that some area of science won't be useful," he noted. "This has to do with the unpredictability of useful results."[27]

There are many excellent examples of the unpredictability of useful results. In his 1995 lecture, Gomory cited how esoteric research in the 1920s in quantum mechanics, which addressed the "baffling puzzle of electrons that behaved like waves one moment and particles the next," influenced solid-state physics in the 1930s and led, after World War II, "to an improved understanding of the fundamentals of crystals and solids" that in turn led to "a better grasp of the role of trace impurities and their effect on the flow of electrons." This led to the transistor and transistors then led to improved computers and electronics. Slightly more than 30 years separated the "emergence of an esoteric and apparently useless field of scientific study from its enormous everyday impact."[28]

An oft-cited example of how research in the physical sciences led, over a winding and uncertain road, to an important medical breakthrough is the story of how equally esoteric research in quantum mechanics later led to magnetic resonance imaging (MRI). By the 1920s, physicists understood the basic structure and properties of the atom and its parts and they also understood that atomic particles, and sometimes nuclei themselves, spin on their axes, generating a magnetic field. Over the ensuing decades, physicists explored the magnetic properties of atoms and molecules to further understand how nuclei are affected by neighboring atoms and how atoms are bound together to form molecules. Otto Stern and Walther Gerlach found in 1921 that the application of a strong magnetic field to an atom would align its nucleus with or against the magnetic field. Isidor Isaac Rabi and his colleagues at Columbia, building on this knowledge, developed during the 1930s a technique called molecular beam magnetic resonance that allowed them to "see" the internal structure of molecules, work that led to the Nobel Prize for Rabi in 1944. In 1945, teams led by Felix Bloch and Edward Purcell, working independently of each

[23] Vannevar Bush, *Science—The Endless Frontier: A Report to the President*, Washington, D.C.: U.S. Government Printing Office, 1945.

[24] Frank Press, "Science and Technology in the White House, 1977 to 1980: Part 1," *Science* 211: 139-145 (1981), and "Science and Technology in the White House, 1977 to 1980, Part 2," *Science* 211: 249-256 (1981). President Carter argued that, after years of declining research support, his Administration provided an 11 percent real increase in funding for long-term research that would "harness the American genius for innovation to meet the economic, energy, health, and security challlenges that contront our nation." James Earl Carter, State of the Union, 1981, http://odur.let.rug.nl/~usa/P/jc39/speeches/su81jec.htm.

[25] U.S. House of Representatives, Committee on Science, *Unlocking our Future: Toward a New National Science Policy*, September 24, 1998. Committee for Economic Development, *America's Basic Research: Prosperity through Discovery*, New York: Committee for Economic Development, 1998. Council on Competitiveness, *Going Global: The New Shape of American Innovation*, Washington, D.C.: Council on Competitiveness, 1998.

[26] Michael McGeary and Philip M. Smith, "The R&D Portfolio: A Concept for Allocating Science and Technology Funds," *Science*, 274: 1484–1485 (1996).

[27] Ralph Gomory, "An Unpredictability Principle for Basic Research," in AAAS, *Science and Technology Yearbook, 1995*, Washington, D.C.: AAAS, 1995, pp. 5–17.

[28] *Ibid*., pp. 6–7.

other, developed a technique for measuring nuclear magnetic resonance in condensed matter—the magnetic resonance in the nuclei of molecules in liquids and solids—as opposed to the isolated molecules that Rabi had worked on. This pioneering work led to a better understanding of atoms and molecules and won Bloch and Purcell the Nobel Prize in 1952. No one had yet envisioned its eventual medical application, and before this happened, chemists saw how measuring magnetic resonance could allow them to examine and determine molecular structures by placing a compound in a tube and then placing it in a magnet. This useful application in chemistry was only transformed into a technology with potential medical applications another quarter-century later when, in 1971, Paul Lauterbur pioneered a way to project this resonance as an image. Today, MRI technology is used to examine tissue by converting into images the radio signals emitted by the nuclei of hydrogen atoms when they are acted upon by a powerful magnet.[29]

To be sure, there are numerous other important examples of advances in one field preparing the way for important new research in others. Digitization and visualization of images have played key roles in biomedical research and medical procedure. Indeed, invasive body diagnostics like laparoscopic knee surgery or colonoscopy diagnostics are only possible because of the electronic revolution. Similarly, advances in computer science and bioinformatics have been critical to the Human Genome Project and genomic research generally.

The "investment portfolio" approach called for by McGeary and Smith, therefore, is designed to address the sort of "unpredictability of useful results" demonstrated by such cases as the transistor and MRI through the creation of a portfolio of diverse investments in science and engineering. It calls, therefore, for decision makers at all levels to consider a wide range of factors in considering investments in science and technology. They should:

(i) look beyond next year's budget request;
(ii) ensure diversity in scientific and technological advances by providing adequate investment in each field (and, within fields, funding multiple approaches to research problems and multiple modes, in terms of individual investigators, small groups, research centers, and large-scale facility-based groups, as appropriate by field);
(iii) achieve an appropriate mix of all components of a successful research program (projects, facilities, equipment, and people);
(iv) consider what other sectors are funding, including industry;
(v) consider cooperative efforts with researchers in other countries; and
(vi) see that each program, no matter how focused on a practical goal, invests adequately in long-term fundamental research.[30]

This disciplined strategy is key to ensuring the long-term success and leadership of science and engineering in the United States.

Two kinds of analysis that can inform federal funding decisions for science and technology are examinations of research funding by field across time and comparisons U.S. research by field to that of other countries or regions.

A recent analysis of federal financial support for research by field concluded that the current system for allocating resources neither systematically analyzes the long-term effects of funding trends by field nor ensures that national priorities are taken into account. This report, *Trends in Federal Support of Research and Graduate Education*, states:

> The current system for allocating research funding does not necessarily ensure that national priorities are taken into account. In the highly decentralized U.S. system of support for science and engineering, most research funding is

[29]Federation of American Societies for Experimental Biology (FASEB), "Magnetic Resonance Imaging (MRI)," in FASEB series, *Breakthroughs in Bioscience*, http://www.faseb.org/opar/break. National Academy of Sciences (NAS), "Magnetic Resonance Imaging," in NAS series, *Beyond Discovery: The Path From Research to Human Benefit*, http://www.beyonddiscovery.org.

[30]McGeary and Smith, "The R&D Portfolio," p. 1485.

> tied to the missions of federal agencies rather than national needs more broadly conceived, such as technological innovation and economic growth. If a mission changes—for example, defense strategy in the post-Cold War worked—support of certain fields of research may decline for reasons that are entirely defensible in terms of the affected agency's priorities but not necessarily defensible in terms of the research opportunities in and productivity of those fields and their potential contributions to national goals. The evidence of changing agency priorities and portfolios is encouraging. In a rapidly changing world, it would be disturbing if spending systems were static. But there is no process for reviewing systematically the effects of these decentralized decisions on the health of research fields and the supply of human resources with reference to a set of national goals.[31]

The report goes on to demonstrate how analyses of trends in federal agency research budgets and their impact on research and graduate enrollment by field can yield important insights. The report draws largely on existing data available from the National Science Foundation's Division of Science Resources Statistics.

Second, the analysis of what is "adequate investment" in each field requires close analysis that can also be informed by international comparisons. The analysis of adequate investment by field should compare the productivity of a field in the United States to that in other countries or regions—a comparison referred to as international benchmarking. COSEPUP has undertaken several experiments in international benchmarking—in mathematics, materials science and engineering, and immunology. These experiments have demonstrated that benchmarking data can be gathered fairly readily for analysis. The analysis should then determine how much funding the federal government should provide by field, taking into account industry funding, positive externalities and uncertainties of research, desired leadership status, and the results of international comparisons.[32]

Given this, further analyses of adequacy in support, such as time series analyses of funding trends by field or international benchmarking, are therefore warranted for a number of fields, particularly certain fields in the physical sciences and engineering whose funding was cut in the 1990s and may be cut again under current budget proposals. (See Appendix A for a description research funding trends by field for the period 1993 to 1999.) For example, the Administration describes the Department of Energy's Office of Science as "the Nation's leading sponsor of research in the physical sciences" but also proposes a budget for this office that would decrease by 0.4 percent in constant dollars from FY 2002 to FY 2003. The Administration also proposes a decrease in FS&T at the Department of Defense, the other major supporter of research in the physical sciences and engineering, of 1.9 percent in constant dollars. For science and engineering in the aggregate, total research increased 11.7 percent from 1993 to 1999. As federal support for research in the physical sciences already decreased by 17.7 percent during that period, a detailed analysis of the effects of such trends on key fields could reveal much about whether the U.S. is maintaining its world-class status in these areas and, if we are not, what role the federal government should play in addressing this issue.[33]

If increases for specific fields are warranted, based on the analysis outlined above, funding could be made available across federal agencies through guidance provided by OMB and the White House Office of Science and

---

[31]National Research Council, *Trends in Federal Support of Research and Graduate Education,* Washington, D.C.: National Academy Press, 2001, p. 5.

[32]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Experiments in International Benchmarking of U.S. Research Fields*, Washington, D.C.: National Academy Press, 2000. The National Science Board has endorsed the concept of international benchmarking. National Science Board, *Federal Research Resources: A Process for Setting Priorities* (NSB 01-156) Arlington, VA: National Science Foundation, 2001, argues as follows: "Both relative and absolute international statistical data and assessments should be a major component of the information base to support Executive Branch and Congressional research budget allocation decisions. International benchmarking of U.S. research performance and capabilities on a regular basis responds to the growing globalization of science and technology and the need for the U.S. to maintain a world-class science and engineering infrastructure." The full text of the NSB recommendations can be found in Appendix B of this report. The Administration has also embraced the concept of international benchmarking. Memorandum for the Heads of Executive Departments and Agencies, From John H. Marburger, III, Director, Office of Science and Technology Policy, and Mitchell Daniels, Director, Office of Management and Budget, Regarding FY 2004 Interagency Research and Development Priorities, May 30, 2002, states "If leadership in a particular field is a goal for a program or agency, OMB and OSTP encourage the use of benchmarks to assess the processes and outcomes of the program with respect to leadership."

[33]NRC, *Trends in Federal Support*, p. 43.

Technology Policy early in the annual budget cycle. For example, while advances in biomedical science require research and development drawing on a number of science and engineering fields, recent funding for NIH has generally been spent in accordance with historical patterns. A recent NRC report examining trends in federal research funding concluded that "NIH continued to focus on the life sciences, accounting for most of the 28 percent increase in total federal funding [from 1993 to 1999], and especially the medical sciences. There has been little diversification, at least with respect to the physical sciences and engineering. Mathematics and computer science support has increased substantially but still constitutes less than 1 percent of NIH's research budget."[34] As the domain of biomedical research has broadened to embrace computational scientists, physicists, chemists, and others, NIH funding patterns could likewise be broadened to include the work of these scientists. These scientists and their work have been and will be critical to providing the instrumentation that is necessary for advances in areas of biomedical research. The importance of computational science in deciphering the human genome is a case in point.

While the outcomes that stem from our nation's overall investment in science and technology are also influenced by national innovation systems, institutional arrangements, and human resources, a robust and capable publicly funded R&D portfolio across fields is important to the health of the science and engineering enterprise. The nation requires a strong research infrastructure—adequate funding, facilities, and human resources—across science and engineering so that we can both capitalize on opportunities and rise to meet important challenges.

Being among the world leaders across fields, we can capitalize on new discoveries wherever they come from and whenever they occur, so that our industry and nation will be advantaged and will be prepared whenever national goals and challenges shift abruptly and science and technology are called on to address new policy priorities. The current response to terrorism is a key example.

FS&T Spending and Human Resources

To maintain world-class status in science and engineering fields, allowing us to capitalize on opportunities and rise to new challenges, it is important to maintain a world-class cadre of scientists and engineers across these fields. Historically, funding for university research has been critical to this because of the strong linkage in the American science and engineering enterprise between research funding and human resources development, particularly graduate education. "A major objective of the federal/university partnership in research and education historically," the National Science Board writes, "has been to attract high-ability youth into science and engineering careers by providing significant multi-year financial support that is competitively allocated and based on the student's past achievement and future promise."[35]

Trends such as the decline in federal support for university research in the physical sciences and engineering during the 1990s have substantial long-term consequences for future human resources. For example, one can see a correlation between declines in federal funding and graduate enrollment by field. Federal support for university-based research in physics and mathematics decreased by 20.9 percent and 19.9 percent, respectively, from 1993 to 1997. Despite slight upturns in funding, federal spending in these fields was still down in 1999 by 7.4 and 13.5 percent, respectively, relative to 1993. During this period, the number of full-time graduate students in physics declined 22.1 percent and the number in mathematics dropped 18.8 percent. Similarly, the number of Ph.D.s awarded by U.S. universities in these fields declined by 9.1 and 5.3 percent, respectively. These trends are shown in Figures 3 and 4. In contrast, graduate enrollment in health fields grew by 41.5 percent and the number of doctorates awarded in health fields leaped by 17.8 percent during the same time period.[36]

As a result of trends such as these, not only has current research in physics and mathematics been reduced but also our human resources capacity for conducting future research across fields has been eroded. Once human resources in a field are eroded, it can take 10 or more years before they can recover, given the long lead time for

[34]NRC, *Trends in Federal Support*, pp. 67–68.
[35]National Science Board, *Government Funding of Scientific Research* (NSB-97-186), Arlington, VA: National Science Foundation, 1997.
[36]NRC, *Trends in Federal Support.*

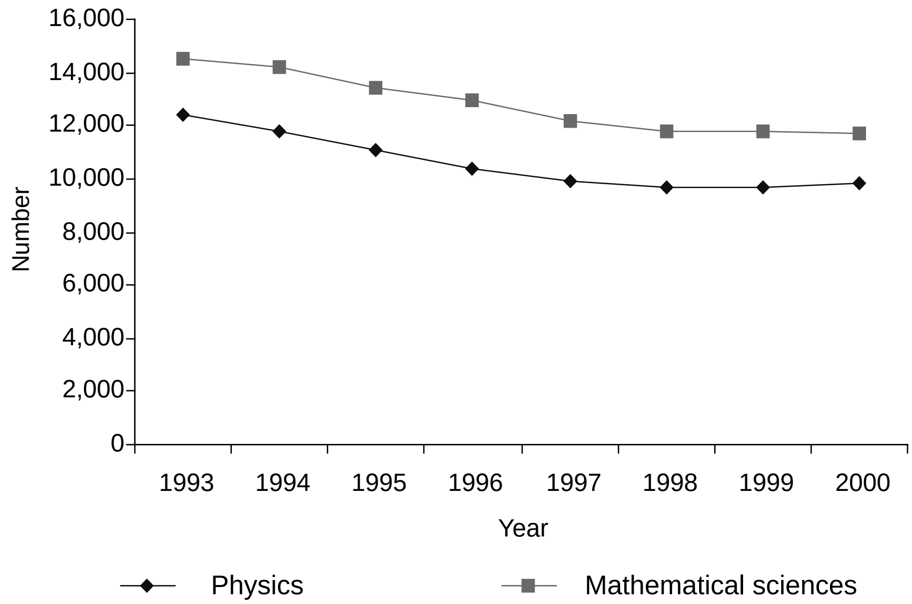

FIGURE 3 Full-time graduate enrollment in physics and mathematics, 1993–2000. Source: National Science Foundation/ Division of Science Resources Statistics, Survey of Graduate Students and Postdoctorates in Science and Engineering.

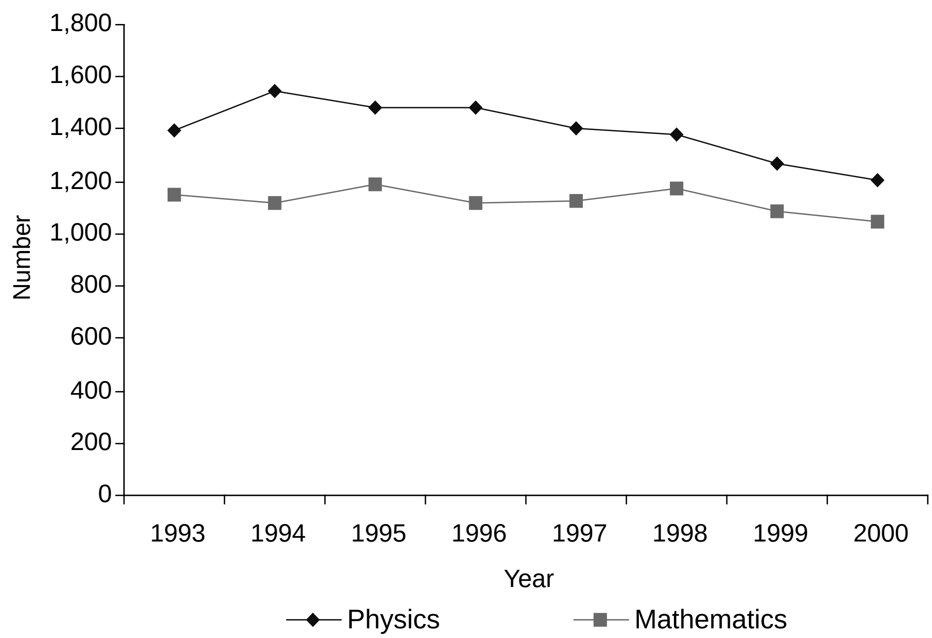

FIGURE 4 Research doctorates awarded by U.S. colleges and universities in physics and mathematics, 1993–2000. Source: National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates

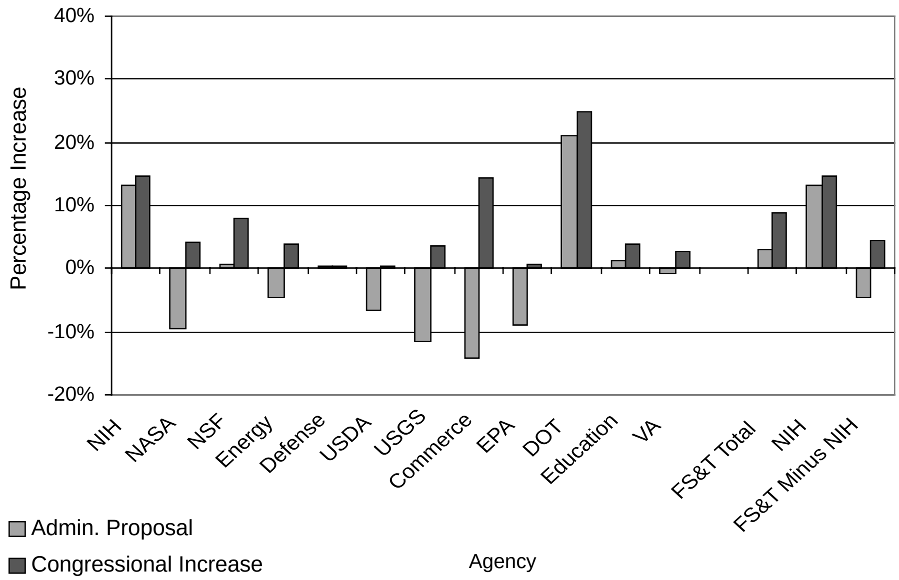

FIGURE 5 Percentage Increase in FS&T Spending Proposed by the Administration Compared with Congressional Appropriation, by Department or Agency, FY 2001 to FY 2002 (constant FY 2002 dollars). Source: *Budget of the United States Government, Fiscal Year 2003*.

doctoral studies.[37] To ensure that the nation can generate and benefit from these opportunities, we must maintain support across fields not only for the research it generates but also to train the future generations of scientists and engineers who will sustain our world-class science.

Budget Action for FY 2003 and FY 2004

In the short run, the Administration and Congress must address questions of both priority and adequacy for FY 2003 and the upcoming FY 2004 budget cycle. The Administration's FS&T budget proposal for FY 2003 addresses issues of priority. It does not, however, deal appropriately with issues of adequacy of funding across the science and engineering portfolio. As in the recent past, the task of preparing a balanced portfolio on federal investments in science and technology for the coming year has been left to Congressional appropriators. Since the late 1990s, advocates for increased funding for NIH have generally also urged increased federal funding across science and engineering. Importantly, Congress has responded with significant funding above Administration requests for NSF and other agencies. Congress will need to consider such arguments again this year.

As seen in Figure 5 and Table 4, Congressional appropriators found themselves in the same position last year. For FY 2002, the Administration recommended a large increase for NIH as a first step in fulfilling the President's campaign promise to complete the doubling of that agency's budget. It then proposed flat funding or deep cuts for FS&T in all other agencies (except for Transportation, whose budget is independently governed in part by the

[37]Registered time-to-degree for a doctoral student in science and engineering fields ranges from 6.8 years in the physical sciences and engineering to 7.0 years in the life sciences and 7.5 years in the social and behavioral sciences. Especially in the life sciences, training typically continues beyond the Ph.D. in a series of 2-year postdoctoral positions. T. Hoffer, B. Dugoni, A. Sanderson, S. Sederstrom, R. Ghadialy, and P. Rocque, *Doctorate Recipients from United States Universities: Summary Report 2000*, Chicago: National Opinion Research Center, 2001, p. 47.

Federal Highway Trust Fund). Congress matched, and slightly exceeded, the Administration's recommended increase for NIH. However, it provided at least flat funding or increases for all other agencies, resulting in an overall increase for FS&T in agencies other than NIH, where the Administration had proposed substantial cuts. Congress should again consider adequacy of funding for research across fields as it finalizes appropriations for FY 2003.

QUALITY, RELEVANCE, AND LEADERSHIP

In the meantime, an overarching priority for the Administration in the FY 2003 budget is to begin a process for linking budgeting and investment decisions to management practices and results. Every department or agency—including federal science agencies—has been evaluated in this budget proposal through the lens of the President's Management Agenda. This process has resulted in a rating for each agency on each of the five cross-government initiatives in the Agenda: (i) human capital, (ii) competitive sourcing, (iii) financial management, (iv) e-government, and (v) budget/performance integration. The last of these, in particular, has been of concern to the science community as the administration moves forward with the application of the Government Performance and Results Act (GPRA) and "R&D Investment Criteria," developed by OMB, to federal research programs.

The goal of budget/performance integration for research and development is to better prioritize research and maximize the return on the government's investment. The process involves scoring programs on the basis of the following criteria:

- **Relevance**: R&D programs must be able to articulate *why* this investment is important, relevant, and appropriate. Programs must have well-conceived plans that identify program goals and priorities and identify linkages to national and "customer" needs.
- **Quality**: R&D programs must justify *how* funds will be allocated to ensure quality R&D. Programs allocating funds through means other than a competitive, merit-based process must justify these exceptions and document how quality is maintained.
- **Performance**: R&D programs must have the plans and management processes in place to monitor and document *how well* this investment is performing. Program managers must define appropriate outcome measures and milestones that can be used to track progress toward goals, and assess whether funding should be enhanced or redirected.[38]

In its FY 2003 budget proposal, the Administration marks the first application of these criteria to specific science programs in one agency: the Department of Energy. As a result of this application, the Administration has identified higher- and lower-performing programs in DOE research and development and proposes shifting funding away from programs that it considers to have a lower benefit-cost ratio to others in the same field that seem to yield a higher benefit-cost ratio. The Administration plans to extend these criteria to other research programs in the FY 2004 budget cycle.

OMB's R&D Investment Criteria deliberately echo the recommendations of the National Academies on the application of GPRA to federal research programs. However, the Academies have recommended that federal agencies evaluate the results of science and engineering research by focusing on the quality of the research they support, the relevance of the research to their missions, and the *global leadership* of the research.[39] The federal government should expect that the research it funds will produce results relevant to clearly identified research problems, whether in fundamental research or in more applied programs. It should also expect the research programs it funds to produce quality results over the long run. But most of all, the research produced by a federally funded program should contribute to the global leadership of the United States in relevant fields.

[38]U.S. Office of Management and Budget, "Research and Development Criteria," Draft, May 3, 2002.

[39]The National Academies, *Evaluating Federal Research Programs: Research and the Government Performance and Results Act*, Washington, D.C.; National Academy Press, 1999.

As the Administration extends the application of applied R&D criteria throughout the government for use in the development of the FY 2004 budget, it should be mindful of the difference between a focus on "performance" and a focus on "leadership." Performance measures that focus too heavily on near-term results may provide strong incentives to focus on conservative goals. Performance measures that focus on results without assessing whether a program has adequate funding may penalize a program by decreasing its funding, when, in fact, the program requires increased funding. A focus on leadership, in contrast, would examine the adequacy of funding, the ability to promote risky research on the frontiers of knowledge that may or may not produce anticipated results, whether the infrastructure of science is sufficient, and the development of science and engineering human resources for the future. The goal of federal funding for research is to maintain a science and engineering enterprise that is world-class across fields and preeminent in fields relevant to national priorities.

The Administration should also be mindful of the alternatives for reviewing research programs. Collection of data from R&D managers about their programs is one vehicle for collecting information useful to a program review. However, external review of agency programs can serve as an additional, and potentially valuable, tool for ensuring that federal funds for research are being properly managed and directed toward important national goals and long-term needs and opportunities. External review can take many forms. For example, in 1959, the National Bureau of Standards (now NIST) requested the NRC establish a standing board to conduct periodic and continuing reviews of its laboratory programs. The most recent of these reviews examined NIST's Measurement and Standards Laboratory in 2001.[40] As another example, the National Science Foundation, under its GPRA plan, relies on its traditional external Committees of Visitors to review the integrity of its process and the quality of its results over a three-year period, examining one-third of its portfolio each year.[41]

In the long run, however, both the Administration and Congress should consider how to improve the process for drawing on expert advice for identifying the key areas of investment in science and engineering. The National Science Board, in *Federal Research Resources: A Process for Setting Priorities*, has outlined a framework that places a priority on investments that advance important national goals, are ready to benefit from greater investment, address long-term needs and opportunities for federal missions and responsibilities, and ensure world-class science and engineering across fields in the United States. This process would "incorporate input from federal departments and agencies, advisory mechanisms of the National Academies, scientific community organizations representing all sectors, and a global perspective on opportunities and needs for U.S. science and technology." The recommendations from this NSB report are provided in Appendix B of this report.[42]

A key mechanism for obtaining input from the scientific community with regard to specific fields is the process of international benchmarking. As described above, benchmarking yields valuable insights for policy makers and is a type of review that can be undertaken in a cost-effective manner.[43] The Administration should consider the range of options available to ensure that programs are evaluated properly and in a manner that creates incentives for world-class research.

CONCLUSION

The U.S. Office of Management and Budget has developed an effective approach for conceptualizing and tabulating federal investments in science and technology across the federal government—the Federal Science and Technology Budget—that is consistent with a process for managing and targeting federal funding for science and technology programs across federal agencies that the NRC outlined in *Allocating Federal Funds for Science and Technology*. This approach allows the Executive Office of the President to articulate a vision for science and

[40]See for example, National Research Council, *An Assessment of the National Institute of Standards and Technology Measurement and Standards Laboratory, Fiscal Year 2001*, Washington, D.C.: National Academy Press, 2001.

[41]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Implementing the Government Performance and Results Act for Research: A Status Report*, Washington, D.C.: National Academy Press, 2001, p. 116.

[42]National Science Board, *Federal Research Priorities*, p. 4.

[43]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Experiments in International Benchmarking of U.S. Research Fields*, Washington, D.C.: National Academy Press, 2000.

technology across the federal government by establishing short- and long-term priorities. This approach also allows the Administration to analyze funding for science and technology as a long-term portfolio of investments for the future.

Although the Administration has established key FS&T priorities for FY 2003, it has not addressed the issue of adequacy of funding across the FS&T portfolio. It has identified areas where priority-driven research can contribute to the advancement of important national goals and agency missions. It has not, however, focused in this budget proposal on the potential of discovery-oriented research across science and engineering fields.

Indeed, the downward trends in budgets for certain agencies have cut funding for specific fields, particularly in the physical sciences and engineering. Not only do these trends affect the amount of research that can be conducted in the short run, but they put at risk the capacity of the nation's colleges and universities to attract and educate students in key scientific and engineering disciplines. Because FS&T investments and graduate education are closely linked, the reductions in research funding have led to a decreased enrollment of graduate students that poses serious concerns about the nation's strength in science and technology.

The Administration and Congress should revisit the FS&T budget proposals as well, in light of the recommendations of *Making the Nation Safer*. This report outlines the potential impact of science and technology research in seven cross-cutting areas and argues "the realization of this potential will depend on a program of directed basic and applied research and *will require an expansion and coordination of existing S&T programs and funding* if the government's work is to produce effective tools for countering terrorism and ensuring homeland security." (emphasis added)[44] Moreover, the report notes that in order to realize the potential a "balance of investments is critical, across different time horizons as well as across numerous disciplines."[45] Although research on countering bioterrorism conducted by NIH will be productive, research carried out by other agencies, such as NSF, DOE, DOD, and NIST, can also contribute substantially to efforts to counter terrorist threats against the United States. Congress should give careful consideration to the role and funding of science and technology in the proposed Department of Homeland Security.

The Administration has correctly identified the unfortunate practice of earmarking funds for research at specific institutions as a practice that must be curtailed. All of the resources available for science and engineering research must be utilized in their most effective manner, given the important national goals we face. Reducing earmarks is also the responsibility of the research community and must be addressed by following guidelines such as those endorsed by the Association of American Universities.

In addition to eliminating earmarking, other steps must be taken to ensure that federal resources for science and technology are being spent in a productive manner. In developing and implementing its Research and Development Criteria, the administration should seek to verify that the science and technology programs it funds are directly related to the advancement of important national goals, produce high-quality research, and keep our nation among the world leaders in research across fields. External reviews provide one means for examining the efforts of a specific program. International benchmarking provides an important method for analyzing the status of U.S. science in particular fields. The Administration should consider mechanisms such as these as it moves forward with analyses of the outcomes of federal science and technology programs.

---

[44]*Ibid*., pp. 332-334
[45]*Ibid*.

Tables

TABLE 1 Federal Science and Technology Budget, FY 2000–FY 2003 (millions of current dollars)

AGENCIES	2000 Actual	2001 Actual	2002 Est.	2003 Proposed	FY 2001–FY 2002 (Percent Change)	FY 2002–FY 2003 (Percent Change)
National Institutes of Health	17,827	20,438	23,433	27,335	14.7%	16.7%
NASA	7,013	7,789	8,113	8,774	4.2%	8.1%
Space Science	2,606	2,760	3,034	3,428	9.9%	13.0%
Earth Science	1,734	1,825	1,695	1,639	–7.1%	–3.3%
Biological and Physical Research	839	944	828	851	–12.3%	2.8%
Aero-space technology	1,834	2,260	2,556	2,856	13.1%	11.7%
National Science Foundation	3,903	4,437	4,795	5,036	8.1%	5.0%
Dept. of Energy	4,338	4,911	5,099	5,027	3.8%	–1.4%
Science Programs	2,820	3,218	3,240	3,285	0.7%	1.4%
Renewable Energy	306	370	386	408	4.3%	5.7%
Nuclear Energy	226	261	244	251	–6.5%	2.9%
Energy Conservation	577	619	641	589	3.6%	–8.1%
Fossil Energy R&D	409	443	588	494	32.7%	–16.0%
Dept. of Defense	4,541	4,944	4,961	4,952	0.3%	–0.2%
Basic Research (6.1)	1,136	1,271	1,305	1,336	2.7%	2.4%
Applied Research (6.2)	3,405	3,673	3,656	3,616	–0.5%	–1.1%
Dept. of Agriculture	1,759	1,885	1,890	1,913	0.3%	1.2%
CSREES Research and Education	488	514	552	563	7.4%	2.0%
Economic Research Service	67	69	70	82	1.4%	17.1%
Mandatory Research Grants	120	120	0	0	–100.0%	0.0%
Agricultural Research Service	866	936	1,017	1,014	8.7%	–0.3%
Forest Service	218	246	251	254	2.0%	1.2%
Dept. of the Interior (USGS)	847	918	950	904	3.5%	–4.8%
Dept. of Commerce	826	828	948	861	14.5%	–9.2%
NOAA (Oceanic/Atmospheric Research)	285	325	362	297	11.4%	–18.0%
NIST	541	503	586	564	16.5%	–3.8%
Environmental Protection Agency	683	746	750	797	0.5%	6.3%
Dept. of Transportation	593	521	651	548	25.0%	–15.8%
Highway Research	490	387	448	421	15.8%	–6.0%
Aviation Research	103	134	203	127	51.5%	–37.4%
Dept. of Education	317	363	377	431	3.9%	14.3%
Special Educ. Research and Innovation	64	77	78	78	1.3%	0.0%
NIDRR	86	100	110	110	10.0%	0.0%
Res., Dev., and Dissemination	167	186	189	243	1.6%	28.6%
Dept. of Veterans Affairs	321	363	373	409	2.8%	9.7%
FS&T Total	42,968	48,143	52,340	56,987	8.7%	8.9%
NIH	17,827	20,438	23,433	27,335	14.7%	16.7%
FS&T Total minus NIH	25,141	27,705	28,907	29,652	4.3%	2.6%
NIH as percentage of FS&T Total	41.5%	42.5%	44.8%	48.0%	—	—

Source: *Budget of the United States Government, Fiscal Year 2003*

TABLE 2 Federal Science and Technology Budget, FY 2000–FY 2003 (millions of constant FY 2002 dollars)

AGENCIES	2000 Actual	2001 Actual	2002 Est.	2003 Proposed	FY 2001–FY 2002 (Percent Change)	FY 2002–FY 2003 (Percent Change)
National Institutes of Health	18,640	20,887	23,433	26,852	12.2%	14.6%
NASA	7,333	7,960	8,113	8,619	1.9%	6.2%
Space Science	2,725	2,821	3,034	3,367	7.6%	11.0%
Earth Science	1,813	1,865	1,695	1,610	–9.1%	–5.0%
Biological and Physical Research	877	965	828	836	–14.2%	1.0%
Aero-space technology	1,918	2,310	2,556	2,806	10.7%	9.8%
National Science Foundation	4,081	4,534	4,795	4,947	5.7%	3.2%
Dept. of Energy	4,536	5,019	5,099	4,938	1.6%	–3.2%
Science Programs	2,949	3,289	3,240	3,227	–1.5%	–0.4%
Renewable Energy	320	378	386	401	2.1%	3.8%
Nuclear Energy	236	267	244	247	–8.5%	1.0%
Energy Conservation	603	633	641	579	1.3%	–9.7%
Fossil Energy R&D	428	453	588	485	29.9%	–17.5%
Dept. of Defense	4,748	5,053	4,961	4,864	–1.8%	–1.9%
Basic Research (6.1)	1,188	1,299	1,305	1,312	0.5%	0.6%
Applied Research (6.2)	3,560	3,754	3,656	3,552	–2.6%	–2.8%
Dept. of Agriculture	1,839	1,926	1,890	1,879	–1.9%	–0.6%
CSREES Research and Education	510	525	552	553	5.1%	0.2%
Economic Research Service	70	71	70	81	–0.7%	15.1%
Mandatory Research Grants	125	123	0	0	–100.0%	0.0%
Agricultural Research Service	905	957	1,017	996	6.3%	–2.1%
Forest Service	228	251	251	250	–0.2%	–0.6%
Dept. of the Interior (USGS)	886	938	950	888	1.3%	–6.5%
Dept. of Commerce	864	846	948	846	12.0%	–10.8%
NOAA (Oceanic/Atmospheric Research)	298	332	362	292	9.0%	–19.4%
NIST	566	514	586	554	14.0%	–5.5%
Environmental Protection Agency	714	762	750	783	–1.6%	4.4%
Dept. of Transportation	620	532	651	538	22.3%	–17.3%
Highway Research	512	396	448	414	13.3%	–7.7%
Aviation Research	108	137	203	125	48.2%	–38.5%
Dept. of Education	331	371	377	423	1.6%	12.3%
Special Education Res. and Innovation	67	79	78	77	–0.9%	–1.8%
NIDRR	90	102	110	108	7.6%	–1.8%
Res., Dev., and Dissemination	175	190	189	239	–0.6%	26.3%
Dept. of Veterans Affairs	336	371	373	402	0.5%	7.7%
FS&T Total	44,927	49,201	52,340	55,979	6.4%	7.0%
NIH	18,640	20,887	23,433	26,852	12.2%	14.6%
FS&T Total minus NIH	26,287	28,314	28,907	29,128	2.1%	0.8%
NIH as percentage of FS&T Total	41.5%	42.5%	44.8%	48.0%	—	—

Source: *Budget of the United States Government, Fiscal Year 2003*
Note: Deflators used to convert current dollar to constant FY 2002 dollars are derived from the GDP (chained) price index in Table 10.1, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. GPO, 2002.

TABLE 3 Proposed Percent Change in Constant Dollars in FS&T Spending for Agencies and for Science Programs, FY 2002–FY 2003

	Percent Change, FY 2002–FY 2003
AGENCIES	
Dept. of Health & Human Services (NIH)	14.6%
Dept. of Education	12.3%
Dept. of Veterans Affairs	7.7%
FS&T TOTAL	***7.0%***
NASA	6.2%
Environmental Protection Agency (EPA)	4.4%
National Science Foundation (NSF)	3.2%
FS&T minus NIH	*0.8%*
Dept. of Agriculture	–0.6%
Dept. of Defense	–1.9%
Dept. of Energy	–3.2%
Dept. of the Interior (USGS)	–6.5%
Dept. of Commerce	–10.8%
Dept. of Transportation	–17.3%
PROGRAMS	
USED Research, Development, and Dissemination	26.3%
USDA Economic Research Service	15.1%
NASA Space Science	11.0%
NASA Aero-space technology	9.8%
FS&T TOTAL	***7.0%***
DOE Renewable Energy	3.8%
DOE Nuclear Energy	1.0%
NASA Biological and Physical Research	1.0%
FS&T minus NIH	***0.8%***
DOD Basic Research (6.1)	0.6%
USDA CSREES Research and Education	0.2%
USDA Mandatory Research Grants	0.0%
DOE Science Programs	–0.4%
USDA Forest Service	–0.6%
USED Special Education Research and Innovation	–1.8%
USED NIDRR	–1.8%
USDA Agricultural Research Service	–2.1%
DOD Applied Research (6.2)	–2.8%
NASA Earth Science	–5.0%
NIST	–5.5%
DOI U.S. Geological Survey	–6.5%
DOT Highway Research	–7.7%
DOE Energy Conservation	–9.7%
DOE Fossil Energy R&D	–17.5%
NOAA (Oceanic and Atmospheric Research)	–19.4%
DOT Aviation Research	–38.5%

Source: *Budget of the United States Government, Fiscal Year 2003*
Note: Deflators used to convert current dollar to constant FY 2002 dollars are derived from the GDP (chained) price index in Table 10.1, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. GPO, 2002.

TABLE 4 Proposed Change in FS&T Spending by Department or Agency, FY 2002–FY 2003 (in millions of constant dollars)

AGENCIES	Change
Dept. of Health and Human Services (NIH)	3,419
NASA	506
National Science Foundation	152
Dept. of Education	46
Environmental Protection Agency	33
Dept. of Veterans Affairs	29
Dept. of Agriculture	–11
Dept. of the Interior (USGS)	–62
Dept. of Defense	–97
Dept. of Commerce	–102
Dept. of Transportation	–113
Dept. of Energy	–161
FS&T Total	3,639

Source: *Budget of the United States Government, Fiscal Year 2003*
Note: Deflators used to convert current dollar to constant FY 2002 dollars are derived from the GDP (chained) price index in Table 10.1, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. GPO, 2002.

TABLE 5 Multi-Agency R&D Initiatives, FY 2001–FY 2003 (millions of constant FY 2002 dollars)

MULTI-AGENCY R&D INITIATIVES	2001 Actual	2002 Est.	2003 Proposed	FY 2001–FY 2002 (Percent Change)	FY 2002–FY 2003 (Percent Change)
Networking and IT R&D	1,805	1,844	1,857	2.2%	0.7%
National Nanotechnology Initiative[a]	474	579	667	22.1%	15.2%
Climate Change Research	1,766	1,670	1,723	–5.4%	3.2%

[a]Climate Change Research includes both the U.S. Global Change Research Program and the proposed Climate Change Research Initiative.
Source: *Budget of the United States Government, Fiscal Year 2003*
Note: Deflators used to convert current dollar to constant FY 2002 dollars are derived from the GDP (chained) price index in Table 10.1, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. GPO, 2002.

TABLE 6 Federal Science and Technology Budget, FY 2001 Actual, FY 2002 Administration Proposal, and FY 2002 Congressional Appropriation (constant FY 2002 dollars)

AGENCIES	2001 Actual	2002 Proposed	Proposed Increase	2002 Est.	Actual Increase
National Institutes of Health	20,438	23,112	13.1%	23,433	14.7%
NASA	7,789	7,038	–9.6%	8,113	4.2%
National Science Foundation	4,437	4,472	0.8%	4,795	8.1%
Dept. of Energy	4,911	4,682	–4.7%	5,099	3.8%
Dept. of Defense	4,944	4,963	0.4%	4,961	0.3%
Dept. of Agriculture	1,885	1,759	–6.7%	1,890	0.3%
Dept. of the Interior (USGS)	918	813	–11.4%	950	3.5%
Dept. of Commerce	828	711	–14.1%	948	14.5%
Environmental Protection Agency	746	679	–9.0%	750	0.5%
Dept. of Transportation	521	631	21.1%	651	25.0%
Dept. of Education	363	368	1.4%	377	3.9%
Dept. of Veterans Affairs	363	360	–0.8%	373	2.8%
FS&T Total	48,143	49,588	3.0%	52,340	8.7%
NIH	20,438	23,112	13.1%	23,433	14.7%
FS&T Total minus NIH	27,705	26,476	–4.4%	28,907	4.3%

Source: *Budget of the United States Government, Fiscal Year 2003*
Note: Deflators used to convert current dollar to constant FY 2002 dollars are derived from the GDP (chained) price index in Table 10.1, in U.S. Office of Management and Budget, *Budget of the United States Government, Fiscal Year 2003: Historical Tables*, Washington, D.C.: U.S. GPO, 2002.

Appendixes

APPENDIX A

National Research Council *Trends in Federal Support of Research and Graduate Education*[1]

Key Findings (Excerpted from Executive Summary)

KEY FINDINGS

The following findings form the basis for the conclusions and recommendations of this study:

- Federal research funding in the aggregate turned a corner in FY 1998 after five years of stagnation. Total expenditures were up 4.5 percent in FY 1998 over their level in 1993. A year later, in FY 1999, they were up 11.7 percent over 1993. FY 2000 and FY 2001 saw continued growth in budget authority for research. These increases are accounted for primarily by NIH. Indeed, increases in NIH appropriations kept federal research funding from falling even lower in the mid-1990s and have dominated more recent growth in overall research funding (see Fig. ES-1). Moreover, NIH is slated by the current administration for substantial increases in the next several years while most other agencies would receive flat or reduced funding for research.
- Although federal research funding began to increase after 1997, the new composition of federal support remained relatively unchanged. In 1999, the life sciences had 46 percent of federal funding for research, compared with 40 percent in 1993. During the same period, physical science and engineering funding went from 37 to 31 percent of the research portfolio.
- Whereas 12 of the 22 fields examined had suffered a real loss of support in the mid-1990s (four by 20 percent or more), by FY 1999 the number of fields with reduced support was seven. However, five of these—physics, geological sciences, and chemical, electrical, and mechanical engineering—were down 20 percent or more from 1993.
- The fields of chemical and mechanical engineering and geological sciences had less funding in 1999 than in 1997. Funding of some fields—including electrical engineering and physics—improved somewhat from 1997 to 1999 but not enough to raise them back up to their 1993 levels.
- Other fields that failed to increase or had less funding after 1997 included astronomy, chemistry, and atmospheric sciences.

[1]National Research Council, *Trends in Federal Support of Research and Graduate Education*, Washington, D.C.: National Academy Press, 2001. Figures referenced in the "Key Findings" reproduced in this Appendix can be found in the report, available on-line at http://www.nap.edu/catalog/10162.html.

- One field that had increased funding in the mid-1990s, materials engineering, experienced declining support at the end of the decade. Its funding was 14.0 percent larger in 1997 than in 1993, but that margin fell to 3.0 percent in 1998 and 1.5 percent in 1999.
- The fields whose support was up in 1997 and has continued to increase include aeronautical, astronautical, civil, and other engineering,[2] biological and medical sciences; computer sciences; and oceanography.
- Fields that, like overall research expenditures, turned a corner were environmental biology, agricultural sciences, mathematics, social sciences, and psychology. Their funding, which was less in 1997 than in 1993, exceed the 1993 level by 1999 (see Fig. ES-2).
- More recent actions on federal budgets for research, including the first installments in doubling of the NIH budget over the 5 years ending in FY 2003, will increase the current divergence between the life sciences and other fields unless other fields receive substantially larger increases than proposed.
- The decline in the support of many of the physical science and engineering fields is partly attributable to the fact that the budgets of their principal sponsoring agencies (e.g., DOD, DOE, and the National Aeronautics and Space Administration [NASA]) did not fare as well as the NIH budget and partly to the fact that the agencies with growing budgets, especially NIH and the National Science Foundation (NSF), did not increase their support of those fields and in some cases reduced it. At the same time, some fields (e.g., computer sciences, oceanography, and aeronautical engineering) experienced substantial growth even though their largest 1993 funders were agencies with shrinking budgets (e.g., DOD and NASA). These fields did so by maintaining their level of funding from agencies with declining budgets and by picking up additional support from other agencies.
- The patterns in federal funding of basic research and research performed at universities are similar to that for overall funding of research but somewhat more favorable, suggesting that by the late 1990s agencies were tending to protect basic and university research relative to applied research and other performers.
- Although federal funding of research assistant positions through research grants and contracts is but one factor among many in determining the number of Ph.D.'s produced in a field, graduate enrollments and Ph.D. production were generally down in fields that had less federal funding in 1999 than in 1993. Over the next few years, these declines will contribute to an ongoing reduction in the supply of new talent for positions in governmental/nonprofit organizations, industry, academia, and other employment sectors (see Fig. ES-3).
- Data on the composition of industry-funded research are classified by sector rather than by field and thus are not directly comparable to those on federal expenditures. The data show that corporations' spending on research has been increasing but is concentrated in a few sectors such as the pharmaceutical industry and the information technology sector. Electronic components was one industry in which research investment increased as federal support of the most closely related research field, electrical engineering, declined over the decade. Nevertheless, except for a few industries such as pharmaceuticals, only a small fraction (less than 5 percent in computer and semiconductors, for example) of all corporate research and development is basic research. Moreover, private research investment is quite volatile, sometimes subject to wide fluctuation from year to year with or independent of the business cycle.
- The shifts in federal funding of fields were partly the result of congressional (e.g., biomedical research) and presidential priorities (e.g., high-performance computing research and development); but the funding reductions were substantially the product of decentralized decision making by officials in various departments, agencies, and congressional committees, adjusting resources to agency mission needs in a constrained budget environment. Impacts on the overall composition of the federal research portfolio were not considered until FY 2000, when the administration and Congress began to discuss the balance of funding among fields, and the FY 2001 budget cycle, when for the first time balance became an explicit criterion used by the administration in developing its budget request.

[2]Other engineering includes agricultural, bioengineering, biomedical, industrial and management, nuclear, ocean, and systems engineering.

Appendix B

National Science Board
Federal Research Resources: A Process for Setting Priorities[3]

Recommendations
(Excerpted from Executive Summary)

RECOMMENDATIONS

Implementation of a broad-based, continuous capability for expert advice to both OMB and Congress during the budget process would yield immediate benefits to decision makers. There is also a long-term need for a regular, systematic evaluation of the effectiveness of Federal investments in achieving Federal goals for research through the Office of Science and Technology Policy, drawing broad-based input from scientific experts and organizations in all sectors. Complementing both would be improved analyses on research opportunities, needs, and benefits to society; and timely data that trace research investments through the budget process and beyond.

Keystone Recommendation 1

The Federal Government, including the White House, Federal departments and agencies, and the Congress should cooperate in developing and supporting a more productive process for allocating and coordinating Federal research funding. The process must place a priority on investments in areas that advance important national goals, identify areas ready to benefit from greater investment, address long-term needs and opportunities for Federal missions and responsibilities, and ensure world class fundamental science and engineering capabilities across the frontiers of knowledge. It should incorporate input from the Federal departments and agencies, advisory mechanisms of the National Academies, scientific community organizations representing all sectors, and a global perspective on opportunities and needs for U.S. science and technology.

RESEARCH COMMUNITY INPUT ON NEEDS AND OPPORTUNITIES

Presently there is no widely accepted and broadly applied way for the Federal Government to obtain systematic input from the science and engineering communities to inform budget choices on support for research and research infrastructure. The current system often fails to produce advice and information on a schedule useful to the budget process and responsive to needs for broad-based, informed assessments of the benefits and costs of

[3]National Science Board, *Federal Research Resources: A Process for Setting Priorities* (NSB 01-156), Arlington, VA: National Science Foundation, 2001, pp. 4-7.

alternate proposals for Federal support. A more effective system for managing the Federal research portfolio requires adequate funding, staffing, and organizational continuity.

Recommendation 2

A process should be implemented that identifies priority needs and opportunities for research—encompassing all major areas of science and engineering—to inform Federal budget decisions. The process should include an evaluation of the current Federal portfolio for research in light of national goals, and draw on: systematic, independent expert advice from the external scientific communities; studies of the costs and benefits of research investments; and analyses of available data; and should include S&T priorities, advice, and analyses from Federal departments and agencies. The priorities identified would inform OMB in developing its guidance to Federal departments and agencies for the President's budget submission, and the Congress in the budget development and appropriations process.

EXECUTIVE BRANCH ADVISORY MECHANISM

The Executive Branch should implement a more robust advisory mechanism, expanding on and enhancing current White House mechanisms for S&T budget coordination and priority setting in OSTP and OMB. It is particularly essential that the advisory mechanism include participants who are experienced in making choices among excellent opportunities or needs for research, for example, vice provosts for research in universities, active researchers with breadth of vision, and managers of major industrial research programs.

Recommendation 2a

An Executive Branch process for ongoing evaluation of outcomes of the Federal portfolio for research in light of Federal goals for S&T should be implemented on a five-year cycle.[4] A report to the President and Congress should be prepared including a well-defined set of the highest long-term priorities for Federal research investments. These priorities should include new national initiatives, unique and paradigm shifting instrumentation and facilities, unintended and unanticipated shifts in support among areas of research resulting in gaps in support to important research domains, and emerging fields. The report should also include potential trade-offs to provide greater funding for priority activities. The report should be updated on an annual basis as part of the budget process, and should employ the best available data and analyses as well as expert input. Resources available to OSTP, OMB and PCAST should be bolstered to support this function.

CONGRESSIONAL ADVISORY MECHANISM

There is no coherent congressional mechanism for considering allocation decisions for research within the framework of the broad Federal research portfolio. Though improvements in the White House process—particularly expansion of activities and resources available to OSTP—would benefit congressional allocation decisions, one or more congressional mechanisms to provide expert input to research allocation decision are badly needed.

Recommendation 2b

Congress should develop appropriate mechanisms to provide it with independent expert S&T review, evaluation, and advice. These mechanisms should build on existing resources for budget and scientific analysis, such as the

[4] The designation of a five-year cycle for evaluation of the Federal portfolio reflects both the scale of the effort, which would require a longer time than an annual process, and the increasingly rapid changes in science that demand a frequent reevaluation of needs and opportunities for investments.

Congressional Budget Office, the Congressional Research Service, the Government Accounting Office[5], and the National Academies. A framework for considering the full Federal portfolio for science and technology might include hearings by the Budget Committees of both houses of Congress, or other such broadly based congressional forums.

DEFINITIONS, DATA AND DATA SYSTEMS

High quality data and data systems to monitor Federal investments in research would enhance the decision process. Such systems must be based on definitions of research activities that are consistently applied across departments and agencies and measured to capture the changing character of research and research needs. Improving data will require long-term commitment with input from potential users and contributors, and appropriate financial support.

Recommendation 3

A strategy for addressing data needs should be developed. Such a strategy supported by OMB and Congress and managed through OSTP and OMB would assure commitment by departments, agencies and programs to timely, accessible data that are reliable across reporting units and relevant to the needs for monitoring and evaluating Federal investments in research. Current data and data systems tracking federally funded research should be evaluated for utility to the research budget allocation process and employed as appropriate.

INTERNATIONAL COMPARISONS

Both relative and absolute international statistical data and assessments should be a major component of the information base to support Executive Branch and Congressional research budget allocation decisions. International benchmarking of U.S. research performance and capabilities on a regular basis responds to the growing globalization of science and technology and the need for the U.S. to maintain a world-class science and engineering infrastructure.

Recommendation 4

Input to Federal allocation decisions should include comparisons of U.S. research resources and performance with those of other countries. National resources and performance should be benchmarked to evaluate the health and vigor of U.S. science and engineering for a range of macroeconomic indicators, using both absolute and relative measures, the latter to control in part for the difference in size and composition of economies. Over the long term, data sources should be expanded and quality improved.

FEDERAL RESEARCH BENEFITS TO THE ECONOMY AND SOCIETY

In addition to monitoring Federal expenditures for research, measuring the benefits to the public of funded research is essential for prudent management. Implementation of this recommendation should be coordinated with Recommendation 3 on definitions and data systems.

Recommendation 5

The Federal government should invest in the research necessary to build deep understanding and the intellectual infrastructure to analyze substantive effects on the economy and quality of life of Federal support for science and technology. The research should include improvements to methods for measuring returns on public investments in research.

---

[5]Sic. Should read “General Accounting Office”.