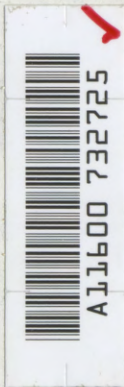


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NATIONAL SCIENCE FOUNDATION AUTHORIZATION
ACT FOR FISCAL YEARS 1981 AND 1982

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HEARING
BEFORE THE
SUBCOMMITTEE ON
HEALTH AND SCIENTIFIC RESEARCH
OF THE
COMMITTEE ON
LABOR AND HUMAN RESOURCES
UNITED STATES SENATE
NINETY-SIXTH CONGRESS

SECOND SESSION

ON

S. 2462

TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES FOR THE
NATIONAL SCIENCE FOUNDATION FOR FISCAL YEARS 1981 AND
1982, AND FOR OTHER PURPOSES

MARCH 25, 1980

DOCUMENTS

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NATIONAL SCIENCE FOUNDATION AUTHORIZATION ACT FOR FISCAL YEARS 1981 AND 1982

TUESDAY, MARCH 25, 1980

U.S. SENATE,
SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, D.C.

The subcommittee met at 10:15 a.m., in room 4232, Dirksen Senate Office Building, Senator Richard S. Schweiker presiding pro tempore.

Present: Senator Schweiker.

OPENING STATEMENT OF SENATOR SCHWEIKER

Senator SCHWEIKER. The Senate Subcommittee on Health and Scientific Research will come to order.

We apologize for the delay.

Our chairman is campaigning. Our acting chairman is sick. Unfortunately, I can only be here about an hour so we will have to keep things short.

I would like to begin by reading the opening statement.

Today, the Subcommittee on Health and Scientific Research will discuss the National Science Foundation Authorization Act, S. 2462, introduced by Senator Kennedy. We will hear testimony from the administration as well as from representatives of organizations that receive NSF grant support.

The activities of the National Science Foundation are critically important to the advancement of scientific knowledge in our Nation. As the major source of support for basic research in the sciences, NSF policies have enormous implications for the Nation's progress in scientific knowledge and technological innovation.

The National Science Foundation also plays a vital role in educating our future scientists—and in increasing public awareness of science and technology.

[The text of S. 2462 follows:]

96TH CONGRESS
2D SESSION

S. 2462

To authorize appropriations for activities for the National Science Foundation for fiscal years 1981 and 1982, and for other purposes.

IN THE SENATE OF THE UNITED STATES

MARCH 20 (legislative day, JANUARY 3), 1980

Mr. ROBERT C. BYRD (for Mr. KENNEDY) introduced the following bill; which was read twice and referred to the Committee on Labor and Human Resources

A BILL

To authorize appropriations for activities for the National Science Foundation for fiscal years 1981 and 1982, and for other purposes.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*
3 That this Act may be cited as the "National Science Founda-
4 tion Authorization Act for Fiscal Years 1981 and 1982".

5 SEC. 2. (a) There are authorized to be appropriated to
6 the National Science Foundation \$1,142,500,000 for the
7 fiscal year 1981 and \$1,256,200,000 for the fiscal year
8 1982.

1 (b) Funds authorized for the fiscal year 1981 will be
2 available for the following categories:

3 (1) Mathematical and Physical Sciences,
4 \$264,200,000.

5 (2) Astronomical, Atmospheric, Earth and Ocean
6 Sciences, \$241,300,000.

7 (3) United States Antarctic Program,
8 \$63,400,000.

9 (4) Ocean Drilling Programs, \$27,300,000.

10 (5) Biological, Behavioral, and Social Sciences,
11 \$182,000,000.

12 (6) Science Education Programs, \$85,700,000.

13 (7)(A) Engineering,

14 (B) Applied Science and Research Applications,
15 \$62,600,000 of which not less than 12.5 per centum
16 shall be expended to small business concerns.

17 (8) Scientific, Technological, and International Af-
18 fairs, \$28,850,000.

19 (9) Cross-Directorate Programs, \$51,950,000.

20 (10) Program Development and Management,
21 \$60,800,000.

22 SEC. 3. Appropriations made under authority provided
23 in sections 2 and 5 shall remain available for obligation, for
24 expenditure, or for obligation and expenditure for periods
25 specified in the Acts making the appropriations.

1 SEC. 4. (a) From appropriations made under section 2(b)
2 (other than amounts available for paragraph (6) of such sec-
3 tion) not less than \$25,000,000 shall be made available for
4 programs designed to improve the participation of women in
5 science.

6 (b) Of the total amount authorized under section 2(b)
7 (6)—

8 (1) \$1,000,000 is authorized for a program of
9 education in appropriate technology;

10 (2) \$2,250,000 is authorized for the program
11 Ethics and Values in Science and Technology; and

12 (3) \$2,500,000 is authorized for the program Mi-
13 norities, Women and the Handicapped in Science.

14 (c) Of the total amount authorized under sections
15 2(b)(1), 2(b)(2), and 2(b)(5) for equipment and instrumenta-
16 tion, not less than 10 per centum shall be made available for
17 grants to two- and four-year colleges for equipment and in-
18 strumentation costing \$35,000, or less.

19 SEC. 5. From appropriations made under this Act, not
20 more than \$5,000 for fiscal year 1981 and such sums as may
21 be necessary for fiscal year 1982 may be used for official
22 consultation, representation, or other extraordinary expenses
23 at the discretion of the Director of the National Science
24 Foundation. His determination will be final and conclusive
25 upon the accounting officers of the Government.

1 SEC. 6. Besides the sums authorized by section 2, not
2 more than \$5,500,000 for fiscal year 1981 and such sums as
3 may be necessary for fiscal year 1982 are authorized to be
4 appropriated for expenses of the National Science Foundation
5 incurred outside the United States, to be drawn from foreign
6 currencies that the Treasury Department determines to be
7 excess to the normal requirements of the United States.

8 SEC. 7. (a) Funds may be transferred among the catego-
9 ries listed in section 2(b), so long as the net funds transferred
10 to or from any category do not exceed 10 per centum of the
11 amounts authorized for that category in section 2.

12 (b) The Director of the Foundation may propose trans-
13 fers to or from any category exceeding 10 per centum of the
14 amounts authorized for that category in section 2. Such a
15 proposal must be transmitted in writing to the Speaker of the
16 House, the President of the Senate, and the Senate Commit-
17 tee on Labor and Human Resources and the House Authori-
18 zation Committee on Science and Technology. The proposed
19 transfer may be made only when—

20 (1) thirty calendar days have passed after submis-
21 sion of the written proposal, or

22 (2) the chairmen of the House Committee on Sci-
23 ence and Technology and the Senate Committee on
24 Labor and Human Resources have both written the

1 Director to the effect that the committees have no ob-
2 jection to the proposed transfer.

3 SEC. 8. (a)(1) Section 15(c) of the National Science
4 Foundation Act of 1950 is repealed.

5 (2) Subsection (d) of section 15 of such Act is redesi-
6 gnated as subsection (c).

7 (b) Section 16 of the National Science Foundation Act
8 of 1950 is amended to read as follows:

9 "APPROPRIATIONS

10 "SEC. 16. To enable the Foundation to carry out its
11 powers and duties, only such sums may be appropriated as
12 the Congress may authorize by law."

Senator SCHWEIKER. In the course of today's hearing, we will examine the responsibilities and achievements of the NSF, review the Federal commitment to the Foundation, and discuss proposed increases in authorization levels.

We have with us today a distinguished group of scientists who will address these issues. Our first panel includes Dr. Richard Atkinson, Director of the National Science Foundation, and Dr. Norman Hackerman, president of Rice University and the Chairman of the National Science Board.

Our second panel consists of Dr. Michael Pelczar, president of the Council of Graduate Schools in the United States; Dr. Thomas Wenzlau, president of Ohio Wesleyan University; and Dr. William Klein, director of the Morris Arboretum.

Before we begin, I would like to take a minute to mention that Dr. Atkinson has resigned his position at NSF and this will be his last appearance before the committee. I would like to take this opportunity, Dr. Atkinson, to commend you for the excellent work you have done as Director. We on the subcommittee have always found your relationship with us to be productive and fruitful. I wish you the best of luck in your future endeavors.

I say that as a ranking member of the minority side as well as for the majority members.

STATEMENTS OF DR. RICHARD C. ATKINSON, DIRECTOR, NATIONAL SCIENCE FOUNDATION; DR. GEORGE PIMENTEL, DEPUTY DIRECTOR, NATIONAL SCIENCE FOUNDATION; AND DR. NORMAN HACKERMAN, PRESIDENT, RICE UNIVERSITY, CHAIRMAN, NATIONAL SCIENCE BOARD, A PANEL

Dr. ATKINSON. I will be brief because you know the Foundation and its activities well. With me at the table is Dr. George Pimentel, Deputy Director of the Foundation. On my far left is Dr. Alex Rich, a professor of biophysics at MIT and a member of the National Science Board. His face may seem familiar to you because he was featured in a recent Newsweek article on recombinant DNA research. In my written statement, I talk about some of the developments in basic research that have occurred in the past 10 years and their implications for industry. Rather than review those, let me comment on recombinant DNA research. Ten years ago, that term did not even appear in the scientific literature or in biology textbooks. But today, research on recombinant DNA, where NSF has played a key role, is mentioned in the business section of many newspapers and magazines because it is making a dramatic impact in a number of industries, particularly the chemical and pharmaceutical industries.

Let me also comment about several aspects of the NSF budget. In the fiscal year 1981 budget, there are three areas of major emphasis. One is mathematical and physical sciences; another is engineering science; and the third is related to the President's domestic policy review on industrial innovation and to existing activities of the Foundation in this area.

The emphasis upon mathematical and physical sciences is designed to correct an imbalance among various fields of basic research. From 1967 to 1980, the overall Federal support for basic research was increased by 8 percent, corrected for inflation. But

the details of that increase disclose some varying trends. Support of the life sciences is up 19 percent, of the environmental sciences, up 34 percent, and of the social sciences, up 7 percent.

But support of the mathematical and physical sciences is down 14 percent. In short, while the support of research has had a fair increase, the support of mathematical and physical sciences has fallen behind. That is why in this budget we have a strong increase for these fields: a 28-percent increase for computer sciences, an 18-percent increase for mathematics, a 16-percent increase for physics and chemistry.

In the engineering sciences, the emphasis is on the pursuit of those aspects of engineering sciences that have the most scientific promise. We recognize that too much of our research support in engineering has been targeted on special, well-defined problems. That targeted work is obviously important, but it must be balanced with less directed work in the engineering sciences.

A key concern of the domestic policy review on industrial innovation was research and development that could facilitate such innovation. During the review, NSF was cited on several occasions for some of its innovative programs in areas related to industrial innovation.

Consequently, our budget contains a special thrust for what we call the industry/university cooperative research program. It features a number of activities designed to facilitate research exchanges between industrial and research scientists. We think these exchanges are healthy. Our purpose is twofold: basic phenomena discovered in the universities will be transferred more quickly to industry, and industry's interests and priorities will be clearly heard in the university science community.

Finally, let me mention the ocean margin drilling program. As you know, the National Science Foundation has supported a drilling program in the deep oceans for a decade or more. The oil industry has explored the continental shelf. Areas not yet adequately explored are the ocean margins, the areas between the deep oceans and the continental shelf. Recent developments have indicated that these are particularly important areas for scientific exploration. The Foundation proposes a major undertaking, a \$700-million program over a 10-year period. We have been able to gain support for this program only under the special condition that oil companies would be responsible for half of the funding; the Federal Government would be responsible for the other half. The ocean margin drilling program represents a special venture by the National Science Foundation, a venture that will be collaborative with the oil industry, but a venture where the NSF would control the program.

I will conclude with a brief quotation, from Prof. Paul Samuelson of the Massachusetts Institute of Technology, a Nobel laureate in economics. About 2 months ago, he remarked that more than half of the growth in U.S. productivity is due to advances of scientific knowledge. His remark emphasizes the contribution of new knowledge to productivity.

[The prepared statement of Dr. Atkinson follows:]

STATEMENT OF DR. RICHARD C. ATKINSON
DIRECTOR, NATIONAL SCIENCE FOUNDATION
BEFORE THE
SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH
OF THE COMMITTEE ON LABOR AND HUMAN RESOURCES
U.S. SENATE
MARCH 25, 1980

MR. CHAIRMAN AND MEMBERS OF THE SUBCOMMITTEE:

We enter this decade with a keen awareness that science has a vital role to play in the years ahead. Our nation's future is closely tied to the strength of our scientific enterprise. In such essential areas as food for the world's growing population, new sources of fuel to replace dwindling oil reserves, the fight against disease, and the assurance of adequate national security, we are profoundly dependent on the new knowledge and technologies that grow out of scientific research. Beyond these fundamental concerns, science must provide the technological development necessary to sustain our economy in the face of increasing competition from abroad and must show us how to protect the life-giving balance of the planet.

At the same time that we address the needs of the decade ahead, we should consider important past activities in the National Science Foundation as they influenced the development of the FY 1981 budget. Despite the inflation of recent years, there has been real growth in the Foundation's research budget during the 1970's although this has been offset in many areas by a decline in basic research funding by

other Federal agencies. NSF support has played a major role in many dramatic scientific developments of the 1970's.

The past 10 years have been a time of extraordinary activity in science, with the pace of discovery being described as "explosive" in many fields. Whole new fields of science have emerged, while the boundaries separating others have begun to disappear. Research cutting across disciplinary lines has increased, a reliable sign of vitality in science, and there has been a convergence of the sciences of living and non-living matter.

New basic knowledge today often has quite immediate implications for society. Our understanding of the genetic code has great significance for agriculture and medicine, is making possible previously unimagined industrial technologies, and may even create new energy sources. Private industry is already engaged in the production of synthetic insulin and interferon, using recombinant DNA techniques, and similar techniques are being applied to the study of nitrogen fixation in plants. New knowledge of the earth's crust not only has laid the basis for further work in the continental margins of great scientific importance, but also has direct and immediate application to the search for oil. Research on the chemistry of the upper atmosphere has made us aware of potential long-term changes in the ozone shield that can have significant consequences for our health and, ultimately, for life on Earth. With advances in computer and materials sciences,

we are now able to place a complete microcomputer on a single chip, a fraction of the size of a thumbnail, while the cost of a chip has remained almost constant. Still further dramatic advances lie ahead with immediate relevance to our productivity and international trade. For example, organic compounds have been prepared with electrical conductivities approaching that of copper.

This drawing together of basic and applied research is not merely fortuitous -- rather, it reflects the increasing role of science and technology in all aspects of our daily life and the growing urgency of national problems containing significant scientific components. In any event, it cannot be said that scientific knowledge today consists of dusty reports lying forgotten on a library shelf -- too many people are eagerly awaiting the latest developments in fundamental knowledge.

These developments in the seventies have been possible because of the Nation's investment in basic science and in the training of scientists over the past 35 years. An important result of that investment has been the availability to scientists of a remarkable array of instruments, from laboratory spectrometers to radio and infrared telescopes, from picosecond time measurement devices to remote sensing satellites, from lasers to synchrotron radiation facilities, from ever-smaller to ever-faster, more powerful computers. On both the macro and micro levels, this instrumentation has given scientists access to new realms of the universe. The seventies have shown us how

important this access is to advances in scientific theory and application.

Thirty-five years ago the Vannevar Bush report, "Science-The Endless Frontier," laid the groundwork for the post-war cooperation between science and government. It is striking to be reminded again how it foresaw the needs of today. Its stress on the role of science as one member of a team, at the same time recognizing that "without scientific progress no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world," is as valid today as it was when it was written. Its call for the Nation to explore the frontiers of science is as imperative today as ever.

With the passage of time, it became clear that the links between fundamental research and applications in addressing selected national goals needed to be strengthened. NSF's applied research effort was formally initiated at the beginning of the decade, building on the Foundation's extensive programs in the physical, biological and behavioral sciences, and engineering. This marked the beginning of NSF support for applied research addressed to critical national problems. The new effort stressed inter-disciplinary research and cooperation among different types of organizations--universities, industrial firms, and State and local governments. The combination of engineering and applied sciences in a recently-created Engineering and Applied Science Directorate is intended to stimulate still further interaction between

basic and applied programs and among different types of research performers, the value of which has proved so important to the vitality of our scientific enterprise.

Other developments of the seventies included increased Foundation support for the social sciences and a recognition that this area of science is coming of age. Congressional amendments to the NSF Act of 1968 made explicit the Foundation's mandate to support the social sciences. Today, NSF carries a major responsibility for Federal support for this field. The importance of this support is amply demonstrated, for example, by the work of Nobel laureates in economics who have received NSF grants.

A significant growth in international cooperation in science also marked the decade just ended. Bilateral scientific cooperation agreements were signed with many countries. The increased exchange of scientific information laid the groundwork for many other types of exchange and communication as demonstrated by the most recent agreement with the People's Republic of China which contributed to improved relations with that country. The National Science Foundation has been responsible for implementing over twenty of these agreements on behalf of the U.S. Government.

Science has always been international in nature, since basic knowledge transcends national boundaries. A growing number of large cooperative undertaking with other nations occurred in the seventies,

many of them managed by NSF. This increase in large international undertakings has been due, in part, to the global nature of many scientific efforts, such as studies of the world's oceans and atmosphere, and in part to the cost and scale of the instrumentation necessary to study these phenomena. The International Biological Program, the International Decade of Ocean Exploration, the Deep Sea Drilling Project, and the Global Atmospheric Research Program are some of the Foundation's significant larger-scale undertakings of the seventies. In the 1970's, the NSF also assumed full responsibility for managing the U.S. Antarctic program, which encompasses a broad range of scientific research in the physical and biological sciences and involves cooperation with other signatory nations of the Antarctic Treaty.

During this decade, increased attention was directed at research to improve the effectiveness of science education, and at education for non-scientists to increase the public's understanding of science. There has been a particular focus on the junior high school level, since this is where general scientific literacy can be increased and where important choices occur on the road to science careers. Special attention has also been given to increasing the participation of women and minorities in science to reduce the significant loss of talent to the Nation from their underrepresentation in science careers. The link between research and teaching in science and the effectiveness of NSF's science education programs over the years played an important part in

the Congressional decision to transfer only a small portion of the Foundation's education programs to the new Department of Education.

The NSF budget request of \$1,148 million for fiscal year 1981 builds on our extensive experience of supporting scientific research and science education at a variety of organizations over the past 30 years. The specific emphases in the 1981 budget reflect many months of deliberation and exchange of views and recommendations on the part of the National Science Board, the Foundation staff, advisory committees, the Office of Science and Technology Policy, and the Office of Management and Budget. Planning for this budget began in earnest almost 20 months ago at the June 1978 meeting of the National Science Board, and the balancing of priorities has continued down to the last possible moment. Concerns for the Nation's future and for the taxpayer's dollar have weighed heavily in these decisions.

The NSF Act places upon the Foundation the key responsibility for strengthening the scientific enterprise nationwide; for fostering the highest calibre of scientists and engineers; and for encouraging the application of science to national concerns. The 1981 budget has been developed with this in mind.

The NSF budget provides for real growth in the level of effort of most NSF supported activities. Because of intensive consultation and careful preparation, we believe the budget is fiscally sound and

responsive to science needs and opportunities. In developing this budget, NSF took special heed of the lag in support for the crucial mathematical and physical sciences, the Administration's initiatives for industrial innovation, and other important opportunities such as Ocean Margin Drilling.

Research Initiatives

Mathematical and Physical Sciences

The goal of the Mathematical and Physical Sciences (MPS) Activity is to develop a fundamental understanding of the physical laws that govern the world and the universe in which we live. To further this goal, basic research activities are supported in the disciplines of mathematics, computer science, physics, chemistry, and in the materials sciences. Special emphasis has been placed on the mathematical and physical sciences because these disciplines contribute to all areas of science, and research results in these fields provide the underlying knowledge for the future technological developments upon which our economic and social well being so intimately depend.

While the FY 1981 budget request emphasized increased research project support for all MPS disciplines, including provision of modern research instrumentation, mathematical sciences and computer sciences are given particular reinforcement with increases of 18% and 28% respectively. Computer research has become primarily theoretical

theoretical science in U.S. universities, and the emergence of modern integrated circuit technology presents both the opportunity and the means for university-based research to make possible major experimental contributions to this important and growing field. Because mathematics is characterized by its universality, the power of its abstractions and its use as a tool in all of the sciences, its support is essential to progress on all fronts.

Astronomical, Atmospheric, Earth, and Ocean Sciences

The Astronomical, Atmospheric, Earth, and Ocean Sciences Activity supports basic research in selected disciplines that will increase our knowledge of the natural environment on earth and in space. It is distinguished from other directorates by its emphasis on observational rather than experimental science. Due to this characteristic, acute problems of program support are caused by inflation and obsolescence of expensive equipment. Also, as a consequence of the program's global reach, much of its observational costs derives from the long distances that must be covered in the conduct of the desired research, and from the rigors of hostile environments. It is also distinguished from other directorates because it is responsible for most of the large science undertakings of NSF -- the major research centers such as the Kitt Peak National Observatory and the National Center for Atmospheric Research, the oceanography research fleet and associated shore-support

facilities, and such special activities as the U.S. Antarctic Program and the proposed Ocean Margin Drilling Program. Noteworthy highlights within this Directorate include:

-Funding has been completed for the construction of the Very Large Array and the first year of full VLA operations is now scheduled. Demands for use of the VLA are so heavy that it is already oversubscribed by users. Another important task relates to a new 25 meter diameter millimeter-wave telescope for which detailed design and specifications will be developed. With these and other instruments, important investigations of organic interstellar molecules necessary as building blocks for life in the universe will be pursued. The Air Exchange(SEARES) project will continue its investigations, including the measurements of the rate of transport across the sea-air interface of a large number of materials.

-The Consortium for Continental Reflection Profiling (COCORP) is continuing its study of the continental crust using deep seismic reflections. Recent research discovered an extensive layer of horizontal sedimentary rocks buried beneath an area of metamorphic rocks east of the Appalachian Mountains. This discovery highlights a region of the U.S. that may have hitherto unsuspected deposits of oil and gas.

-A multi-disciplinary project in the Bering Sea has revealed a complex system of oceanic fronts and interfront zones that are directly related to the transfer of energy and food materials to higher forms of marine life in that highly productive area. These findings and on-going research may contribute to a better understanding of marine ecosystems on the other continental shelves as well.

Biological, Behavioral, and Social Sciences

The goal of the Biological, Behavioral, and Social Sciences (BBS) Activity is to expand knowledge and understanding of biological and social phenomena. The range of research supported includes acquiring rigorous physical and chemical information on the fundamental molecules of living organisms, the system-level interrelationships of organisms and their environment, the complex learning and behavior patterns of human beings, and the interactions of social, economic and cultural organizations and institutions. Through such research it is expected that new possibilities will be provided for human development and health, increased options for improving the quality of life, and greater opportunities for economic and social progress. For example, fundamental research supported by NSF on the brain and behavior has discovered knowledge now being applied to neurological and mental disease.

As in the case of other basic research units of NSF, funding has been increased for the BBS program subactivities. Because of the

truly revolutionary developments that have occurred in our understanding of the genetic code, and its implications for agriculture, pharmaceuticals and health related problems, increased emphasis is being given to Physiology, Cellular and Molecular Biology with increases for :

- studies of cell-cell interactions to increase our understanding of hormones and their receptors as well as self-recognition of cells in development and differentiation, and,
- procurement of instrumentation and development of new instrumentation;
- studies of membrane structure and function including pathways and movements of substances through membranes; and
- research on the structure and function of macromolecules especially on the mechanism of heredity in the context of gene structure and functioning, biosynthesis of macromolecules, and the regulation of enzyme activity.

Engineering and Applied Science

The Foundation's Engineering and Applied Science (EAS) Activity seeks to strengthen the Nation's engineering and applied science research base and enhance the links between fundamental research and applications in addressing selected national goals. This is accomplished by identifying and supporting basic research across a broad spectrum of the engineering sciences, applied research, and

related activities that have the highest potential for contributing to the understanding and resolution of significant societal problems.

On July 1, 1979, the National Science Foundation formed the Engineering and Applied Science (EAS) Directorate by combining the Engineering activities within the Foundation with the Applied Science and Research Applications Directorate. Many activities between the two were highly complementary. By combining these organizations, NSF is now better able to:

- Strengthen the engineering programs of the Foundation by giving them a single, more visible place in the NSF organization;
- Enhance NSF's program of applied and problem-focused research by providing a broader base of science and engineering on which to build; and
- Recognize the key role of engineering in the transfer of science into technology by placing the Foundation's major engineering, industry-related, and problem-oriented efforts in one Directorate.

Recognizing the importance of university-based engineering that is not tied to immediate or planned applications, the NSF is proposing a significantly increased investment to take advantage of important opportunities and to compensate for previous support deficiencies. In

particular, attention will be focused on microstructures and computer engineering research. Such an effort will address research in areas where the U.S. has recently been lagging in comparison with foreign countries, and also direct research toward a field which has high potential for productivity improvement and industrial innovation. We plan also to emphasize engineering energetics, with a focus on upgrading facilities for plasma chemistry and arc technology. Another thrust is in thermodynamics and mass transfer, with support for research in novel and energy-efficient separation processes.

Additionally, important directions of EAS include examination of the impact on the economy of a transition from heavily-regulated to less-regulated industries and services; work in areas of manufacturing processes and materials handling; and efforts in earthquake hazards.

The FY 1981 program request provides for upgrading university research laboratories in all NSF Directorates supporting research. Many of these laboratories have outdated facilities which limit the research techniques or instrumentation that can be used.

This frequently results in less than optimal return on the investment of Federal dollars for support of research and can result in deferral or even loss of the scientific opportunities previously identified. The FY 1981 budget request represents a first step toward alleviating this situation. Federal funds will be matched with an equal amount of non-Federal funds from academic institutions.

Industrial Innovation

Industrial innovation -- the development and commercialization of new products and processes -- is an essential element of a strong and growing American economy. In order to foster the Nation's competitive capability and entrepreneurial spirit in the decades ahead, the President initiated a "Domestic Policy Review" in April 1978 to identify appropriate government actions to encourage industrial innovation.

On October 31, 1979, the President sent a Message to Congress announcing a series of measures to help ensure the continued role of the United States as a world leader in industrial innovation. Because NSF had a major role in experimenting with some of the areas singled out for innovation, the Foundation has been assigned important selected responsibilities to implement the Administration's initiatives.

Industry/University Cooperation

International competition and the practice of other industrialized nations of combining the resources of industry, universities, and the government in concerted R&D efforts in certain markets have created new challenges for America. This competition demands more cooperative efforts among industry, universities, and government to increase U.S. productivity. One such effort is to couple academic research capabilities to industrial needs.

By so doing companies may expand their R&D capability without a commitment of industrial personnel or funds on a long term basis. The NSF, in FY 1981, in response to a Presidential initiative, is increasing its industry/university cooperative research efforts markedly. These efforts are designed to stimulate the research programs of both industry and universities. They will also help provide appropriate incentives to ensure that there are improved opportunities for university and industry research laboratories to keep American science at the cutting edge of progress, thus giving our industries a technical edge in worldwide competition.

Small Business Research Efforts

It is well established that there is a high incidence of technological innovation among small and medium sized firms. These firms often involve university scientists and engineers as consultants, thereby linking themselves with university research capabilities. NSF is trying to add to the number of small science and technology firms, and to increase the opportunities for small businesses to make greater

contributions to the national research effort by developing innovative products and undertaking high risk, potentially high pay-off research ideas.

The NSF Small Business Innovation program is a three-phase program. The first two phases are designed to test the feasibility of an innovative idea or concept, the research competence of the firm and to provide initial funding of promising projects in order to attract follow-on private support. The last phase is the development phase in which commercial objectives are pursued with private capital. Since its inception the program has made considerable progress--three solicitations have been issued with participation by many firms and large businesses. As a result of heightened emphasis in the program the number of solicitations will be increased as well as the range of topic areas.

In FY 1981, the Foundation's program has been substantially augmented to aid small business research efforts, bringing the total amount for small business participation, primarily in applied research efforts to approximately \$13 million.

Technology Centers

The NSF University-Industry Cooperative Research Center program encourages research partnerships between industrial firms and

university research laboratories to accelerate industrial innovation and stimulate scientific research. The centers established under this program are involved in science and technology that is common to more than one industrial sector. Such science and technology is referred to as 'generic' because it is not product or process specific. Examples include polymers, corrosion prevention and control, and high impulse welding and joining. In many of these generic areas, advances depend on sophisticated understanding of materials, surface corrosion, and heat transfer. One of the most successful centers has been the Polymer Research Center at MIT where a combination of firms are participating in projects such as mathematical modeling of injection molding and improving the impact resistance of fiber-reinforced polyester. This Center has had a rapid transition from federal to industrial support and is now receiving no Federal funding.

The Foundation will establish one or more generic technology centers in FY 1981 as part of a larger Federal effort designed to enhance industry-university cooperation. The centers will be jointly funded by industry and government, and substantial public benefits are expected.

Ocean Margin Drilling

Beyond the continental shelf is an extensive area, the Ocean Margin, which is overlain by an immense thickness of sediment. This area consists of the Continental Slope and the Continental Rise, and more

than half of the world's marine sediments have been deposited there. The margins, which mark the transition between continent and deep ocean, are the "new frontier" of geologic exploration. They represent the largest scientific unknown in geology today, and they are also the largest unexplored area where we might expect to find hydrocarbons. The bulk of the sediments are in water more than 6,000 feet deep, too deep for any existing drill ship to handle.

The FY 1981 budget request includes \$10 million, to be matched by the U.S. petroleum industry, to embark on a 10-year Ocean Margin Drilling Program. The scientific results from this program are expected to be as revolutionary in scope as those from the NSF funded Ocean Sediment Coring Program.

The Ocean Margin Drilling (OMD) project will attack the most important resolved problems in the plate tectonics hypothesis as well as problems that have emerged from 11 years of Deep Sea Drilling Project efforts. The major new initiative of OMD will be an extensive investigation of the ocean margins. The passive margins with their thick sediment cover, e.g. the U.S. east coast, represent a major frontier for geologic exploration. Besides its great scientific importance, work on the deeply submerged ocean margins will constitute the first major effort to establish the geologic framework for determining the natural resource potential of these areas. To carry out this program it will be

necessary to drill and core in water depths from 6,000 feet to 13,000 feet down to a depth of 20,000 feet in the ocean bottom with complete environmental protection i.e., riser, well control, blow-out prevention. Drilling with such complete environmental protection has to date, never been attempted in water deeper than about 5,000 feet. No existing deep ocean drilling platform has the ability to meet these requirements, but the government-owned Glomar Explorer has been identified as an excellent candidate.

Science Education

With the passage of the Department of Education Organization Act, Congress has reaffirmed the role of NSF in Science Education by specifying five areas of responsibility for the Foundation. These are 1) scientific career development; 2) continuing education of scientific personnel; 3) increasing participation of women, minorities and the handicapped in science careers; 4) conduct of R&D applied to science learning at all educational levels and dissemination of such results; 5) informing the general public of the nature of science and technology and of attendant values and public policy issues. This is the strongest and most complete articulation of NSF responsibilities that has ever appeared in legislation.

In pursuing these responsibilities the Foundation will place special emphasis on four priority thrusts. The first of these is the

improvement of science education for the early adolescent. This entails focusing continued effort at a point of high opportunity, the junior high and middle school years.

The second priority thrust relates to out-of-classroom or informal science learning experiences. This is an important factor in the general development of the public's understanding of science, and is of great importance in interesting and motivating children to study science. The motivational aspects of informal, out-of-classroom science learning in the current decade are expected to play an important role in the development of the cadre of scientists of the future.

This year a third priority thrust has been added to the above continuing concern -- revitalization of college science teaching. For the past several years, higher education (undergraduate institutions in particular) has been affected by a series of events which have, in a cumulative way, affected the quality and currency of college teaching of science. To counter this trend, the Foundation is proposing to give priority, as a major new thrust of FY 1981, to the updating of the subject-matter competence of college science faculty.

The fourth of the thrusts is that of improved access of underrepresented minorities and women to careers in science and engineering. The matter of career access, while related to the early

adolescence thrust, is of sufficient importance to continue to set this subject forward as a special science education concern.

With respect to careers for women in science, there is some evidence that the situation is improving, undoubtedly aided by shifts in the attitudes of society in general as well as by programs such as career workshops and other activities at the pre-college level designed to address the underrepresentation of women in science and technology.

The Congress has remained interested and instrumental in this important area. The data shows that between 1976 and 1978 employment of women scientists and engineers increased significantly faster than men--17.4% vs. 2.8%. Almost 40 percent of the increase in the employment of women took place among engineers--traditionally a male-dominated field. Other fields in which women made substantial gains include environmental sciences, psychology, life sciences and computer sciences.

While these trends are encouraging, it is still true that women are underrepresented in most aspects of the Nation's science and technology enterprise. With the increasing importance of science and technology in our society we can no longer afford to bypass this important talent pool. I believe the longer range outlook can be viewed optimistically, and our efforts in this area will continue.

Key FY 1981 objectives related to the priority thrusts of science education include:

- Support research on how science and mathematics are learned development of more effective instructional techniques and materials for use at all levels of education;
- Provide high quality training in science for specially selected students in programs ranging from the junior high school through the graduate levels;
- Provide for subject-matter revitalization of both pre-college teachers of science and undergraduate science faculty;
- Assist in the improvement of undergraduate science instruction at 2-year and 4-year colleges;
- Assist faculty at two-year and four-year colleges having substantial undergraduate but limited doctoral programs in science and engineering to acquire needed equipment to conduct quality research. This will enable young scientists particularly to maintain and improve their research capabilities and to compete successfully for regular scientific research project support; and
- Improve the public's understanding of science and how it affects their daily lives thus increasing the ability of citizens to participate knowledgeably in the resolution of science-related public policy issues.

International Science Activities

Many NSF science activities are international in scope, and international scientific cooperation has become increasingly important in the past decade. In FY 1981, the Foundation will establish a cooperative research effort with the People's Republic of China. This work will encourage cooperative scientific activities based on mutual benefit and reciprocity in basic biological, social, mathematical and physical sciences. The program will include cooperative research, symposia and scientific visits, but its implementation is dependent upon formal agreement on details with Chinese authorities. NSF also hopes to increase its cooperative work with Western European countries. Our experience in the Antarctic for the past 24 years has demonstrated that science can maintain an effective means of interchange and friendly communication even in times of severe political stress among nations. NSF hopes to continue to conduct a wide range of research support activities that will involve the cooperation of many nations for the benefit of all peoples.

Conclusion

To summarize the highlights presented above, I wish to stress that basic research in the physical sciences and engineering is setting the pace for the NSF program in FY 1981. Basic research in mathematics and the physical science is extremely important in extending the base of scientific knowledge and it also holds promise for advances that can lead to practical applications.

Engineering retains its basic research characteristics but is now more closely allied with applications and applied research activities to improve the flow of basic research results from concept to use.

NSF also provides support for applied research in selected areas where there is good potential for the research results to contribute to improved technology and productivity, both essential in our national efforts to deal with inflation and to provide more and better jobs for U.S. workers.

In the conduct of this research, the NSF is cognizant of the benefits of diversified and widespread performer pool, and the local as well as national importance of a strong science base. For this reason, NSF has established an experimental program to stimulate competitive research with its purpose to broaden participation in scientific research. Seven states are currently in the program and three additional states are included in the FY 81 plan.

During the seventies, the search for fundamental knowledge was singled out by each Administration as being increasingly important to the Nation. This commitment was reiterated in the 1981 budget message of the President. Despite the effort to keep the Federal budget from rising in real terms, it was deemed important to increase funds in few critical areas. Basic research was one of four such areas identified.

In the words of the President..."We benefit today...from the investments in science made decades ago." The FY 1981 NSF Budget reflects the investment concept and is worthy of Congressional concurrence to assure that we shall reap similar returns tomorrow. A summary budget table is attached to my statement. I urge your support of the full program.

Mr. Chairman, I will be happy to answer any questions the subcommittee may have.

Senator SCHWEIKER. Dr. Hackerman, do you have a statement?

Dr. HACKERMAN. I have a statement that I would like to have included in the record.

Senator SCHWEIKER. Yes. We will put all statements completely in the record.

Dr. HACKERMAN. The National Science Board has been deeply involved in the formulation of the NSF budget for fiscal year 1981 through its policymaking and long-range planning process and through the NSB Committee on the Budget. That committee goes into the detail of the budgetmaking process.

The Board strongly endorses the proposed fiscal year 1981 program and the priorities indicated in it, and hopes that the Congress will also endorse it.

Senator SCHWEIKER. You were very brief. I commend you.

I will even have time to ask you a question.

Because of your position on the Science Board, you and Dr. Atkinson both point out that the National R. & D. spending is increasing again.

What factors do you think are positive in that respect to encourage this trend?

Dr. HACKERMAN. The increase itself is a positive factor. As Dr. Atkinson pointed out, there have been some peaks and valleys over the past several years, and there are some areas of the sciences and engineering that have not been supported as well as they might have been. Indeed, because all science is interrelated, the loss in support of mathematical and physical sciences, I think, will be felt in the other sciences as well.

For instance, one of the great reasons for the advances made in the past few years has been the increased sophistication of instrumentation. We have very sensitive instruments that have been developed in the physical sciences. It is very important for us to maintain support of these sciences on a broad front.

[The prepared statement of Dr. Hackerman follows:]

March 24, 1980

Statement of Dr. Norman Hackerman
Chairman, National Science Board
Before the Subcommittee on Health and Scientific Research
Committee on Human Resources
United States Senate
March 25, 1980

Mr. Chairman, Members of the Committee:

I am pleased to be present today to express the views of the National Science Board on the National Science Foundation's (NSF) proposed program for fiscal year 1981. The Board, through its policymaking functions and long-range planning activities, has been deeply involved in the formulation of this program and strongly endorses the priorities expressed in it.

In keeping with the need to control inflation and help balance the Federal budget, the Board has examined carefully the Foundation's priorities. They emphasize the investment nature of basic research and the importance of science and technology in the Nation's future. The strength and international competitiveness of the country's scientific capability must be maintained, and this program takes steps to do so.

Among the thrusts of particular interest in the program is the strengthening of basic research, with an emphasis on areas underlying industrial productivity and innovation, especially in the physical sciences, engineering, and computer science. A welcome associated development is the effort to upgrade university research laboratories through funding for instrumentation and for refurbishing outdated facilities.

In response to a Presidential directive, the Foundation's industry/university cooperative research efforts will increase to stimulate the research programs of both industry and universities. A related effort will assist in strengthening small business research activities, providing the potential for an increase in their contribution to the national research effort.

Another special initiative, the Ocean Margin Drilling Program (OMD), is a logical extension of the successful Deep Sea Drilling Project. It is an attractive convergence of scientific goals, resource exploration, and technological development, and will involve the U. S. petroleum industry. The National Science Board has followed closely the development of this proposed program and believes that it can be of great scientific importance. In addition, the OMD Program will aid in the development and application of deep water technology and will be an important step in the early evaluation of continental margins as a source of hydrocarbons and other mineral accumulations. It offers new opportunities for extensive and profitable collaboration among NSF, other Federal agencies, industry, and foreign countries.

The National Science Foundation is the only Federal body which has as its broad charter responsibility for the overall health of fundamental science and engineering in the United States. The NSF enabling legislation assigns policymaking functions to the National Science Board and the administration of the Foundation to the Director. The policies established by the Board for the support of science and engineering and the

development of scientific manpower are implemented through the programs of the Foundation.

The Board also assists in the formulation of major national science policies, particularly as they relate to the general state of science in the Nation. It initiates studies to identify promising areas of research to add to the fund of knowledge, to improve the quality of life, and to assist in the solution of national societal problems. It assesses and reports on the status and health of science and its various disciplines.

The National Science Board includes twenty-four part-time Members, appointed by the President with the advice and consent of the U. S. Senate, and the Director of the Foundation ex officio. The term of office of Members is six years, expiring on May 10 of the even years. Thus, terms of eight Members will expire this year. The current membership of the Board is shown in Appendix I.

Recommendations for membership on the Board are sought, on behalf of the President, from the major scientific, engineering, and educational societies and associations as specified in the Act. All recommendations received from all sources are forwarded to the White House for consideration together with the joint recommendations of the Board and Director.

In formulating its recommendations, the Board considers those factors stated in Section 4(c) of the National Science Foundation Act of 1950, as amended. Professional qualifications are the primary consideration, as well as public service, geographical

distribution, and balance among professional fields (including science education, law, and public affairs). Also weighed are management capability, representation of women and minority groups, and representation of various types and sizes of educational and research organizations and industry.

In addition to the recommendations made via the Board, and the joint recommendations of the Board and the Director, the President receives recommendations from members of the Congress and from many other interested individuals and organizations. From this array the President then makes a selection and submits nominations to the Senate for consideration by the usual nomination procedure.

The Board is thus constituted of a wide variety of people interested in science, engineering, and science education, with a breadth of backgrounds and differences in opinion. The Members have a continuing interest in undergraduate education, since graduate education would deteriorate without good undergraduate systems. Seven former NSB Members have been from predominantly undergraduate institutions. Nonacademic institutions are represented by seven present NSB Members. Four, Dr. Raymond L. Bisplinghoff, Dr. Lewis M. Branscomb, Mr. Herbert D. Doan, and Dr. W. N. Hubbard, Jr., are industrial executives.

The Board meets its policymaking responsibilities in a number of ways, depending largely on its committees, listed in Appendix II. As noted earlier, it is extensively involved in long-range planning,

the determination of priorities, budgeting, and the development of new programs. One aspect of the process is identification by the Board and staff of longer term concerns which may affect many fields of science. Background information on these issues and on the anticipated future environment is prepared by NSF staff. At the June planning environment review, held under the aegis of the Planning and Policy Committee, the Board discusses such topics, formulates recommendations, and considers possible actions.

The topics considered by the Board last year included the support of young investigators and young faculty. Several possible programs were described, and the positive and negative aspects of each were discussed. The Committee on Role of NSF in Basic Research, chaired by Dr. Alexander Rich, who is present today, was asked to examine further these possible programs; it will provide recommendations to the Board some time in the near future.

A second topic explored in June 1979--reevaluation of NSF research funding mechanisms--has led to further study of new methods of financing research equipment and mechanisms for making small grants to scientists primarily at four-year colleges. The Ad Hoc Committee on Big and Little Science will bring recommendations on these items to the Board.

Another component of the Board's planning activities is the examination of the scientific and program priorities of the Foundation's long-range plans. Guidance is provided through the Committee on Budget, in the preparation of the multi-year cost estimates.

As the Foundation's input to the President's proposed budget develops, the Board keeps in close touch with events.

Status of Science Reviews--1980 provides background for the Board in its planning and budgeting activities and may also be of interest to the Congress and others considering the future of the scientific enterprise. Developed by the Board and Foundation staff, these reviews are an annual series of reports summarizing the judgments of the individual NSF program directors about the current directions and opportunities in the fields of science supported through each directorate. Continuing attention is given to describing the role of the Foundation vis-a-vis other sources of support for research and science education in the Nation.

Oversight of the activities of the Foundation is a major NSB responsibility. It is carried out by individual Members' activities, through the Programs Committee, and through the Committee on Audit and Oversight. Within the past year the latter Committee has noted that it is becoming of increasing importance to examine completed projects to determine if the results are consistent with the objectives of the programs under which the awards are funded. Experimentation with measures and mechanisms to determine the nature and quality of work accomplished with NSF support is also underway within the Foundation.

Other means by which the Board discharges its oversight responsibilities include receipt of program reviews at NSB meetings, participation by the Members in site visits to the National

Centers and other NSF-supported facilities and activities, and attending and reporting upon meetings of the NSF Advisory Council and other Foundation advisory committees.

The National Science Foundation Act of 1950, as amended, requires that the Board assess the status and health of science and its various disciplines, including such matters as national resources and manpower, in reports rendered annually to the President for submission to the Congress. The first report, Toward a Public Policy for Graduate Education in the Sciences, was published in 1969. The Eleventh NSB Report, Science Indicators--1978, was transmitted by the President to the Congress on November 19, 1979.

From this latest report some conclusions can be drawn about the current state of science and technology in this country. Certainly there are some areas that must be watched carefully, but, overall, our scientific enterprise remains sturdy. Some highlights of the report are listed below.

- The U. S. investment in research and development (R&D) is much greater than in most countries, both in terms of expenditure and in scientific and technical personnel. However, Japan and West Germany have been increasing their R&D investments more rapidly than has the United States.

- U. S. universities and colleges have made a significant contribution to the building of world scientific and technical capabilities. They have contributed to the development of foreign

universities and have also assumed the role of training many foreign scientists and engineers.

- Other nations are advancing in terms of economic growth and technical prowess. From the viewpoint of global development and that of our own Nation, this is a positive sign.

- National R&D spending levels have begun to advance following a long period of reduced support.

- Basic and applied research expenditures, in real dollars, have been rising since 1976. Basic research is supported primarily by Federal sources; the Government has taken the position that "prudent planning for the future demands a deliberate and continued commitment to basic research."*

- Total national expenditures for basic research have grown during the period from 1976 to 1979 in constant dollar terms following a period of reduced spending between the late 1960's and mid-1970's.

- Applied research, supported substantially by industrial and Federal sources, also increased because of strong Federal interest and improved fiscal conditions in the private sector.

- The most dramatic change in Federal R&D spending has been in energy, which grew at an average annual rate of 33.6 percent between 1974 and 1979.

*Presidential Message on Science and Technology, delivered to the Congress, March 27, 1979.

- Universities and colleges now perform the largest percentage of basic research in the United States. In 1960 this sector spent 36 percent of the Nation's expenditures for basic research; by 1978 it had risen to 52 percent.

- A relatively recent, modest growth in spending for basic research in industry is significant because it may signal the end of the longstanding trend of decreased industrial basic research activity.

- Concerns have been expressed recently about a decline in the quality of the science and engineering work force. There are no direct measures of work force quality, but two measures suggest that it has not decreased: experienced scientists and engineers continue an undiminished participation in training programs; and test scores for prospective graduate students on both the verbal and quantitative components of the Graduate Record Examination remain high and unchanged, both absolutely and relative to non-science fields.

* * *

During the decade of the 1980's, more of this country's citizenry must and will become more scientifically literate. Thus, society, both as a whole and as individual citizens, will have more of an understanding of science; it should and will expect much of science and technology, especially when supported by public funds. Individual scientists or engineers expect that their "bit" of science, in combination with some other bits and frequently in quite unexpected ways, will through technology

contribute to society. The Foundation's program for fiscal year 1981 will help make that possible.

The Board strongly supports the program as contained in the President's Budget. It welcomes the new initiatives proposed by the President for NSF as an expression of his confidence in science and in the Foundation and its approaches to the Nation's problems.

In closing, I would like to note that this is the last occasion on which I will appear before this Committee as Chairman of the National Science Board, as my second term as a Member of the Board will expire this spring. I consider it an honor and a privilege to have had the opportunity to serve on the Board over those twelve years and to have been associated with my fellow Members. Mr. Chairman, it has also been a real pleasure to work with you and the Members of this Committee. I would like to express my personal appreciation and that of my colleagues for your understanding and support of science, engineering, and science education, and the National Science Foundation.

Thank you, Mr. Chairman.

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* * *

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February 22, 1980

NATIONAL SCIENCE BOARD
COMMITTEE STRUCTURE AND MEMBERSHIP

The National Science Foundation Act assigns policymaking functions to the National Science Board and the administration of the Foundation to the Director. The Board's policymaking responsibilities are met initially through the work of its committees.

Except for the Executive Committee, which is a statutory committee, the National Science Board and its Chairman establish the committees of the Board and make appointments to them. At each annual meeting the Board reviews the committee structure and the continuation of the task and ad hoc committees.

Board committees fall into four categories: statutory, standing, task, and ad hoc. The functions of the committees consist of a series of initial charges and such variations as are deemed desirable and useful once the committees are in operation.

The functions and chairmanship of the current Board committees are given below:

A. STATUTORY COMMITTEE

Section 7(a) of the National Science Foundation Act, as amended, states that:

"There shall be an Executive Committee of the Board (referred to in this Act as the 'Executive Committee'), which shall be composed of five members and shall exercise such powers and functions as may be delegated to it by the Board. Four of the members shall be elected as provided in subsection (b), and the Director ex officio shall be the fifth member and the chairman of the Executive Committee."

The Executive Committee has the following responsibilities:

- Fulfills statutory functions: (1) exercises such powers and functions as may be delegated to it by the Board, and (2) renders an annual report to the Board, and such other reports as it may deem necessary, summarizing its activities and making such recommendations as it may deem appropriate. Minority views and recommendations, if any, of members of the Executive Committee are included in such reports.
- Acts on behalf of the Board between meetings on (1) grants, contracts, or other arrangements; and (2) other instances where immediate decision is required. (All such actions are reported to the Board at its next meeting.)

- Considers and approves affiliations of the Director, Deputy Director, and Assistant Directors.
- Coordinates and offers guidance on activities of the Board and its committees.
- Serves as agenda committee for the Board.
- Identifies subjects to be considered by task and ad hoc committees.

B. STANDING COMMITTEES

The standing committees of the Board are continuing committees with definite responsibilities to perform assigned tasks and to present recommendations to the Board. All Members who are not on the Executive Committee are assigned to one of the two standing committees, the Planning and Policy Committee and the Programs Committee.

1. The responsibilities of the Planning and Policy Committee (Dr. W. N. Hubbard, Jr., Chairman, and Dr. Raymond L. Bisplinghoff, Vice Chairman) are as follows:

- Considers policy issues and prepares draft documents including "white papers" on principal planning and policy issues affecting research and science education for subsequent Board consideration.
- Identifies and recommends actions for the Board with regard to policies and practices affecting research and science education in the Nation with particular attention to NSF.
- Develops and coordinates the long-range planning meetings of the Board, and all associated documentation through interaction with NSF staff.
- Identifies national science policy issues and national needs and considers the proper roles of the Federal Government in general and NSF in particular.
- Meets with the Committee on Budget to coordinate planning, policy, and budget processes.

The Planning and Policy Committee has two subcommittees: the Subcommittee on International Science Activities, chaired by Dr. Jewel Plummer Cobb; and the Subcommittee on Science and Society, chaired by Dr. Eugene H. Cota-Robles.

2. The major activities of the Programs Committee (Dr. L. Donald Shields, Chairman, and Dr. Saunders Mac Lane, Vice Chairman) are as follows:

- Reviews proposed programs and makes recommendations to the Board.
- Reviews all proposals for support containing new policy issues or over certain dollar amounts prior to presentation to the Board with Committee recommendations.
- Monitors existing programs and activities.
- Maintains oversight on long-term commitments of the Foundation.
- Schedules formal and informal reviews of programs, especially for input to discussion of the planning environment review document at the long-range planning meetings.

C. TASK COMMITTEES

The task committees of the Board are assigned specified tasks which are sometimes of a short-term nature. These committees are discharged upon completion of these assigned tasks. The one exception is the Committee on Budget which is an ongoing committee.

1. The Committee on Audit and Oversight, chaired by Dr. Lloyd M. Cooke, reviews the requirements for continued functioning of the Action Review Boards and the effectiveness of other oversight mechanisms.

2. The Committee on Budget (Dr. Marian E. Koshland, Chairman, and Dr. Donald B. Rice, Jr., Vice Chairman):

- Provides a focal point for Board participation in budgetary matters, including program priorities.
- Provides advice to the Board on NSF authorization and appropriation issues.
- Helps serve as spokesmen for the Board on NSF budgetary matters with the Congress and the Office of Management and Budget.
- Reexamines priority considerations, based on results of the long-range planning meetings, to integrate (a) immediate priorities into summer and fall budget preparation, and (b) deferred program priorities into fall preparation of long-range planning estimates.

- Meets with Planning and Policy Committee to review results of Board discussion of and actions/guidelines on the planning environment review document for long-range planning meetings.

3. The Committee on Minorities and Women in Science, chaired by Dr. Jewel Plummer Cobb, considers education and research programs to increase the flow into science of (a) ethnic minorities, (b) women, (c) the disadvantaged, and (d) the physically handicapped.

4. The Committee on Role of NSF in Basic Research is chaired by Dr. Alexander Rich. It:

- Monitors NSF's role in support of basic research in the natural and social sciences.
- Examines factors affecting the quality and quantity of basic research being performed and identifies problem areas and adverse trends.
- Formulates mechanisms for Board consideration which will contribute to the general health of basic research.

5. The Committee on Twelfth NSB Report (Dr. John R. Hogness, Chairman, and Dr. Lloyd M. Cooke, Vice Chairman) provides oversight on preparation of the report to the President and the Congress, due March 1980, on the impact of research upon the general welfare.

6. The Committee on Thirteenth NSB Report (Dr. Joseph M. Pettit, Chairman, and Dr. Eugene H. Cota-Robles, Vice Chairman) provides oversight on preparation of Science Indicators--1980, due March 1981.

7. The Committee on Fourteenth NSB Report (Mr. Herbert D. Doan, Chairman, and Dr. Walter E. Massey, Vice Chairman) provides oversight on preparation of the report to the President and the Congress, due March 1982.

D. AD HOC COMMITTEES

Ad Hoc Committees of the Board have specific tasks generally of short duration.

1. The Ad Hoc Committee on Big and Little Science, chaired by Mr. Herbert D. Doan, continues the consideration of the overall Foundation policy on "big" and "little" science and presents recommendations for the Board's approval.

2. The Ad Hoc Committee on Deep Sea and Ocean Margin Drilling Programs, chaired by Dr. Raymond L. Bisplinghoff, monitors and informs the Board of developments regarding the future drilling programs, both in terms of the alternatives that are being considered, the costs, and how those costs might be shared among agencies of the U. S. Federal Government, foreign countries, or other groups.

Senator SCHWEIKER. That leads me to my next question, Dr. Atkinson.

Dr. Atkinson, we have some reason to believe that OMB has asked you to reduce your fiscal 1981 budget by \$75 million and your fiscal 1980 budget by \$25 million.

Where are you planning on making these cuts and how will the budget reductions impact on the programs you have outlined here this morning?

Dr. ATKINSON. We have not concluded our discussions with OMB, and I am not able to give you the details.

Let me say that you have a copy of our ZBB documents, and the cuts we expect to receive from OMB reflect our ZBB priorities. There will be heavy cuts in science education and applied research.

Senator SCHWEIKER. I thank the panel very much. We are sorry for the delay again and we appreciate your participation.

Dr. Pimentel, do you have a statement?

Dr. PIMENTEL. No, sir.

Senator SCHWEIKER. Thank you very much. We appreciate it.

Our next witnesses are Dr. Michael Pelczar, Dr. Thomas Wenzlau, and Dr. William Klein.

STATEMENTS OF DR. MICHAEL J. PELCZAR, JR., PRESIDENT, COUNCIL OF GRADUATE SCHOOLS IN THE UNITED STATES, ON BEHALF OF ASSOCIATION OF AMERICAN UNIVERSITIES; ASSOCIATION OF GRADUATE SCHOOLS; COUNCIL OF GRADUATE SCHOOLS IN THE UNITED STATES; AMERICAN COUNCIL ON EDUCATION; NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND-GRANT COLLEGES; NATIONAL ASSOCIATION OF INDEPENDENT COLLEGES AND UNIVERSITIES; AND ASSOCIATION OF CATHOLIC COLLEGES AND UNIVERSITIES; DR. THOMAS WENZLAU, PRESIDENT, OHIO WESLEYAN UNIVERSITY, ON BEHALF OF THE GREAT LAKES COLLEGES ASSOCIATION AND THE OTHER MEMBERS OF THE INDEPENDENT COLLEGES OFFICE; THE AMERICAN ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES; THE NATIONAL ASSOCIATION OF INDEPENDENT COLLEGES AND UNIVERSITIES; AND DR. WILLIAM KLEIN, DIRECTOR, THE MORRIS ARBORETUM, A PANEL

Dr. PELCZAR. I am delighted to appear here this morning and speak to the National Science Foundation budget.

I am Michael Pelczar. For approximately 17 years I was a microbiologist at the University of Maryland, then vice president for graduate studies and research, and now am president for the Council of Graduate Schools.

Our organization plus the other organizations which I represent are deeply involved in the training and education of the Nation's most highly skilled and technical personnel. They confer virtually all of the advanced degrees and perform most of the federally supported basic research conducted in the country.

The subcommittee meets to consider the fiscal year 1981 authorization for the National Science Foundation at a troublesome time in our history. The challenges that now face us of runaway inflation, of budget deficit, declining productivity and technological innovation, and dependence on foreign oil are felt by all of us. As a

people we seem caught in the situation Dr. Toynbee so accurately described:

As a rule, people feel acute concern about the future beyond the horizon of the present only when the times are out of joint and when the prospects look menacing. In our generation we are living in one of these times of unusually intense stress and anxiety. What awaits us? What are we going to do when it comes upon us? In our present situation, such questions force themselves on our attention.

The points that I would like to address my remarks to involve mainly the maintenance of support for sustained research capacity that will advance our knowledge, produce new knowledge that is capable of being transformed to high level technology which contributes to our well-being in many respects.

Another point, to maintain a high level of modern instrumentation in our laboratories to accomplish this level of research.

The Nation's research universities and colleges have firsthand experience in addressing these menacing and out-of-joint times. Indeed, it is their responsibility to train the best minds of our Nation in undergraduate as well as graduate education and research programs. If we are to address the problems of our time in a responsible manner, we must take the steps necessary to insure that these individuals are fully trained and prepared to address the problems before us. We must insure a flow of the people and resources necessary to sustain a stable and productive research environment in the Nation's research institutions.

As you consider the fiscal year 1981 authorization for the Foundation, we reaffirm our support for the basic research and science education programs of NSF and urge that the Congress continue to recognize the uniquely important role NSF must play if we are to sustain our search for solutions to the problems that beset us. While we are prepared to do our part to address the difficult problems before us, we urge the Congress to take a balanced and responsible approach and to insure that the programs designed to find long-term solutions to our problems will be maintained.

Over 3 years ago, following a prolonged period of decline in support for basic research, the administration initiated a strategy designed to restore Federal investments in basic research to levels comparable to those of almost a decade ago. Recognizing that such investments have brought numerous social, technological and economic benefits, the administration has consistently proposed sustained modest growth in the basic research programs of NSF and several mission agencies. Last year, in a joint statement to the Congress, 40 higher education associations and leading science societies commended this basic research investment policy and urged the Congress to sustain support of the principles of stable balanced and controlled investment for the future. A copy of that statement is appended to my statement.

In the face of declining national productivity and steadily rising inflation, a controlled, coherent investment policy for basic research is absolutely essential if we are to find new ideas and develop solutions to the pressing economic, technological, and social problems which confront our society. The principles set forth in the joint statement remain valid. They assume even added importance in the circumstances now before us.

The fiscal year 1981 budget submitted to the Congress in January recognizes the central importance of NSF among Federal research programs, and it proposes a balanced targeted strategy to address the most pressing needs of basic science. Among them are targeted increases for the physical and mathematical sciences which, between 1967-80, respectively suffered 13.5 percent and 16.7 percent decreases in constant 1972 dollars. Engineering and basic computer sciences also are targeted for a special effort this year. Together these fields are a vital part of the knowledge foundation upon which our economy rests.

Access to state-of-the-art instrumentation now often defines an investigator's ability to compete at the cutting edge of his or her field. In my own field of microbiology, the indispensable microscope has evolved to unprecedented levels of research power and productivity. With these advances, however, have come steadily increasing costs. Many universities have fallen behind in their capacity to maintain state-of-the-art, competitive research laboratories, instruments and equipment.

The fiscal year 1981 budget proposes a \$14.25 million program to begin rehabilitation and renovation of our laboratories. This will be a small but essential step in beginning to mobilize our efforts to address the problem. We commend NSF for taking steps to begin to address these problems and we enthusiastically support these initiatives. Our future research productivity in many fields will depend upon our commitment to improve research instrumentation and to begin the sizable task of rehabilitating our Nation's academic research laboratories.

While we enthusiastically support the bill, one provision is troublesome. Section 4(a) of the bill requires that "not less than \$25 million shall be made available for programs designed to improve participation of women in science." This provision will mandate division of research support from the competitive project system and from instrumentation and facilities needs to undefined activities related to participation of women in science. Recently, Dr. Ann Reynolds, provost of Ohio State University, testified on behalf of several of these same associations in support of the principles and objectives of bill S. 568. She urged the subcommittee to establish a program of research awards designed to provide targeted support for young women scientists. Her testimony on this point is attached. We support the recommendations Dr. Reynolds made.

While we support increased opportunities for women scientists, we must register with the subcommittee our concern that this provision would simply redirect funds, from ongoing research programs to other undefined purposes. No additional funds are provided. In effect, it would tax research programs to meet added program requirements. We therefore urge the subcommittee to either provide additional support for such purposes or to defer action on them until the committee considers the bill S. 568.

In closing, I wish to reiterate our support for the National Science Foundation and to pledge our full cooperation in addressing the problems before us. I will be pleased to respond to questions.

[The prepared statement of Dr. Pelczar follows:]

TESTIMONY

before the

SENATE SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH

on

S.2462

AUTHORIZATION FOR FY 1981 AND FY 1982. THE NATIONAL SCIENCE FOUNDATION

by

Dr. Michael J. Pelczar, Jr.

President

Council of Graduate Schools in the United States

on behalf of

Association of American Universities
Association of Graduate Schools
Council of Graduate Schools in the United States
American Council on Education
National Association of State Universities and Land-Grant Colleges
National Association of Independent Colleges and Universities
Association of Catholic Colleges and Universities

March 25, 1980

Mr. Chairman and Members of the Subcommittee:

I am Michael Pelczar. For approximately 37 years I was a microbiologist at the University of Maryland, then Vice President for Graduate Studies and Research and now am President for the Council of Graduate Schools. It is a pleasure and a privilege for me to present to the Subcommittee our views concerning the FY 1981 authorization of the National Science Foundation. The member institutions of these associations train and educate almost all of the nation's highly skilled scientific and technical personnel. They confer virtually all of the advanced degrees and perform most of the federally supported basic research conducted in the country.

CGS represents approximately 360 institutions. Together these schools grant 99% of the doctoral research degrees and 85% of the master's level degrees of the nation. Almost all of academic basic research funded by the National Science Foundation and by other federal agencies is carried out in the laboratories of these institutions. The Council also has 300 other affiliate institutions in the New England, Southern, Mid-western and Western regional associations of graduate deans.

The Subcommittee meets to consider the FY 1981 authorization for the National Science Foundation at a troublesome time in our history. The challenges that now face us of run-away inflation, of budget deficit, declining productivity and technological innovation, and dependence on foreign oil are felt by all of us. As a people we seem caught in the situation Toynbee so accurately described:

"When life seems satisfactory and secure, most people apparently are not moved to peer into the future further ahead than is required for present and practical purposes. As a rule, people feel acute concern about the future beyond the horizon of the present only when the times are out of joint and when the prospects look menacing. In our generation we are living in one of these times of unusually intense stress and anxiety. What awaits us? What are we going to do when it comes upon us? In our present situation, such questions force themselves on our attention."

The nation's research universities and colleges have first-hand experience in addressing these "menacing" and "out of joint" times. Indeed, it is their responsibility to train the best minds of our nation in undergraduate as well as graduate education and research programs. If we are to address the problems of our time, we must take the steps necessary to insure that these individuals are fully trained and prepared to address the problems before us. We must insure a flow of the people and resources necessary to sustain a stable and productive research environment in the nation's research institutions.

As non-profit institutions, universities and colleges are thoroughly familiar with the devastating impact of sustained high inflation on institutional budgets. For many years they have responded to chronic fiscal pressures. These institutions already have accomplished sustained budgetary retrenchment, continued improved management and energy conservation. They are continuing to pursue these goals and welcome measures designed to reduce the high cost of inflation.

As you consider the FY 1981 Authorization for the Foundation, we reaffirm our support for the basic research and science education programs of NSF and urge that the Congress continue to recognize the uniquely important role NSF must play if we are to sustain our search for solutions to the problems that beset us. While we are prepared to do our part to address the difficult problems before us, we urge the Congress to take a balanced and responsible approach and to ensure that the programs designed to find long-term solutions to our problems will be maintained.

Over three years ago, following a prolonged period of decline in support for basic research, the Administration initiated a strategy designed to restore federal investments in basic research to levels comparable to those of almost a decade ago. Recognizing that such investments have brought numerous social,

technological, and economic benefits, the Administration has consistently proposed sustained, modest growth in the basic research programs of NSF and several mission agencies. Last year, in a Joint Statement to the Congress (attached), forty higher education associations and leading science societies commended this basic research investment policy and urged the Congress to sustain support of the principles of stable, balanced and controlled investment for the future.

In the face of declining national productivity and steadily rising inflation, a controlled, coherent investment policy for basic research is absolutely essential if we are to find new ideas and develop solutions to the pressing economic, technological, and social problems which confront our society. The principles set forth in the Joint Statement remain valid. They assume even added importance in the circumstances now before us.

The FY 1981 budget submitted to the Congress in January recognizes the central importance of NSF among federal research programs, and it proposes a balanced, targeted strategy to address the most pressing needs of basic science. Among them are targeted increases for the physical and mathematical sciences, which, between 1967-1980, respectively suffered 13.5% and 16.7% decreases in constant 1972 dollars. Engineering and basic computer sciences also are targeted for a special effort this year. Together these fields are a vital part of the knowledge foundation upon which our economy rests.

As pressures build this year on the research budgets of other agencies, it will be even more important for the Congress to sustain a renewed commitment to the basic research programs of NSF. Only the Foundation has as its primary mission the support of basic research. Deep cuts in NSF could completely undo the limited efforts of the last three years and set in motion wide-scale program reductions and terminations that will serve only to further retard, rather than encourage, the efforts of our most able investigators as they press the search for answers to our problems.

An essential element of a stable, competitive research environment is modern instrumentation and equipment. State-of-the-art basic research in the sciences and engineering increasingly relies on sophisticated, high-cost analytical instrumentation and equipment. During my own career as a researcher/teacher, and most recently Chief Research Officer of the University, I have participated in and observed the rapid development of the sciences and engineering. I have observed the rapid evolution of the scientist's tools from relatively simple, inexpensive instruments to rapidly developing, highly specialized tools of impressive power and precision.

Access to state-of-the-art instrumentation now often defines an investigator's ability to compete at the cutting edge of his or her field. In my own field of micro-biology, the indispensable microscope has evolved to unprecedented levels of research power and productivity. With these advances, however, have come steadily increasing costs. Many universities have fallen behind in their capacity to maintain state-of-the-art, competitive research laboratories, instruments and equipment. Many of the nation's leading departments are coping now with out-moded facilities and tools. Squeezed by budgetary pressures and repeatedly deferred, the renovation and rehabilitation needs of major research institutions are now of substantial proportion. Last year a brief survey of nine of the nation's research universities, which together conduct about 15% of our total basic research effort, showed that these universities are able to meet only about half of their documented needs for facilities rehabilitation. Many now can meet only a fraction of the costs for necessary laboratory renovation and reinstrumentation.

This, of course, has a direct, long-term effect on quality of basic research and on the quality of advanced training which universities provide for our next generation of scientists and engineers. While we are sensitive to the needs for fiscal restraint and to the requirements to reduce new initiatives at this difficult time, we would point out to the Committee that the backlogged needs for facilities

rehabilitation and reinstrumentation continue to mount. A start must be made soon, if we are to hold our present international competitive position across the fields of science and technology.

The FY 1981 budget proposes a \$14.25 million program to begin rehabilitation and renovation of our laboratories. This will be a small, but essential, step in beginning to mobilize our efforts to address the problem. We commend NSF for taking steps to begin to address these problems and we enthusiastically support these initiatives. Our future research productivity in many fields will depend upon our commitment to improve research instrumentation and to begin the sizeable task of rehabilitating our nation's academic research laboratories.

While we enthusiastically support the bill, one provision is troublesome. Section 4 (a) of the bill requires that "not less than \$25 million shall be made available for programs designed to improve participation of women in science." This provision will mandate division of research support from the competitive project system and from instrumentation and facilities needs to undefined activities related to participation of women in science. Recently, Dr. Ann Reynolds, Provost of Ohio State University, testified on behalf of several of these same associations in support of the principles and objectives of bill S.568, (Women in Science and Technology Equal Opportunity Act). She urged the Subcommittee to establish a program of research awards designed to provide targeted support for young women scientists. Her testimony on this point is attached.

While we support increased opportunities for women scientists, we must register with the Subcommittee our concern that this provision would simply redirect funds. from ongoing research programs to other undefined purposes. No additional funds are provided. In effect, it would tax research programs to meet added program requirements. We, therefore, urge the Subcommittee to either provide additional support for such purposes or to defer action on them until the Committee considers the bill S.568.

In closing, I wish to reiterate our support for the National Science Foundation and to pledge our full cooperation in addressing the problems before us. I will be pleased to respond to questions.

Senator SCHWEIKER. Thank you.

Next we will hear from Dr. Wenzlau. I might say that, in addition to his responsibilities for the independent colleges, I know he is also president of Ohio Wesleyan where my sister and brother-in-law matriculated. I had to mention that.

Dr. WENZLAU. Thank you very much.

I appreciate very much the opportunity to testify before you today on the National Science Foundation budget request for fiscal 1981. I represent the 16 independent colleges and universities which share the Independent Colleges Office, the 338 members of the American Association of State Colleges and Universities, and the 800 members of the National Association of Independent Colleges and Universities. My testimony, and I will try to summarize it, emphasizes a concern our colleges have expressed to Congress for several years regarding the decreasing real dollar support for science education by the Federal Government. We express this concern as educators, as scientists and as citizens.

I wish to make four major points to support those statements and then to comment specifically about certain items in the proposed NSF budget. The four major points are:

One, scientific understanding, a direct result of science foundation, is critical for the progress of our society.

Virtually every public policy decision faced by Congress, by legislators at the State level, by city councilmen and by volunteer directors of various organizations requires scientific understanding. Specific issues, such as the debates on resource conservation, on fluorocarbons, on solar and nuclear energy, on DNA synthesis, on environmental pollution, all illustrate the continuing importance of scientific literacy for all citizens.

The need for a scientifically literate general populace means that we must have strong science education programs in our primary and secondary schools and that qualified teachers for those programs must be provided by equally strong science education in our colleges and universities. The most recent National Assessment of Science showed that science achievement of 9-, 13- and 17-year-olds continues to decline, especially in the physical sciences. There the plunge constitutes a crisis. Many undergraduate students who study science will fill jobs in industry and commerce.

It is abundantly clear that our ability to deal with the complex issues of the modern world depend greatly on scientific advancement and that our political and economic futures are tied closely to our technical progress. The preparation of research scientists also calls for the very best science teaching from grade school through graduate school.

Congress recognized the interdependence of science education and scientific research when it formed the National Science Foundation. The legislation creating the Foundation charged it "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." Congress throughout has understood that neither can proceed effectively or efficiently without the other. Together they provide the knowledge and manpower both essential to solve specific scientific problems.

We firmly believe that the National Science Foundation has ignored this interrelationship to the point that the low level of

support for science education will have a deleterious effect on the quality of scientific research. At the level of expenditures for science education recommended in the National Science Foundation fiscal 1981 budget, real expenditures for science education will have declined 83 percent since 1968. Quite unrealistically, this declining level of real expenditures for science education is somehow expected to undergird significantly expanded levels of scientific research—up 78 percent in real terms since 1968.

While we recognize that the \$9 spent for science education for each \$10 spent for scientific research in 1968 may be excessive for today's needs, it is equally clear that a ratio which allows for only \$1 of expenditure for science education for each \$12 spent for scientific research can only subvert those very research efforts the National Science Foundation seeks to emphasize. Ultimately, our national scientific potential will be in jeopardy.

It is critical, we believe, that this subcommittee recommend to Congress that some reasonable balance be maintained between science education and scientific research expenditures. This balance needs to be established even if the overall NSF budget is subjected to cuts in the interest of the national campaign against inflation. In past testimony we have suggested that \$1 for science education should be spent for each \$3 for scientific research expenditures. This ratio of 1 to 3, we believe, will maintain a critical mutually supportive balance between these two vital activities.

These comments should not be construed to be a criticism of the quantity of resources directed to support scientific research. Quite the contrary. We recognize and support basic research expenditures. But those research dollars can be meaningfully used only if a scientific foundation has been prepared by effective science education. This, in turn, requires a reasonable balance between resources allocated to these two interrelated aspects of scientific progress.

My third major point is related to the significance of what we have chosen to call little science. Many critical discoveries have originated from little science—carried out by one researcher with modest equipment and an equally modest budget. Little science researchers work on college and university campuses on all sizes and all over the country.

They tend to be more concentrated more in some disciplines than in others but possess great and largely untapped potential to make crucial future contributions to new scientific knowledge.

We want to acknowledge the recognition of the potential of "little science" by this subcommittee last year in requiring that 10 percent of the research instrumentation grants awarded by NSF be allocated to 2- and 4-year institutions. This policy, even though modified in conference, has been extremely beneficial to colleges such as those I represent and, we believe, beneficial to the advancement of scientific knowledge.

Fourth, the National Science Foundation mandate concerning science education reads, "To initiate and support * * * programs to strengthen scientific research potential and science education programs at all levels * * *." Science education programs are of two sorts: those which support and sustain the ongoing process of science education and those which respond in some innovative manner to a crisis or new problem. While it may be exciting and

certainly more visible politically to attack new problems, certain basic needs in science are always with us. Updated curricula and materials with teachers trained to use them are a continuing requisite in elementary and secondary schools. Qualified science faculty and reasonably up-to-date instructional scientific equipment are needed for good undergraduate science education. These continuing needs are common to all institutions—large universities, 4-year colleges and community colleges.

Among the National Science Foundation support programs which award grants on a competitive basis to help science departments meet continuing needs. I have included specific comments in my statement on four of these. They are the science faculty professional development; the instructional scientific equipment program. We have a great need for dealing with obsolete equipment, as discussed by Dr. Pelczar, with respect to research equipment. The undergraduate research participation program where students become directly involved with the faculty and where, in fact, research is science education. And, finally, comprehensive assistance to undergraduate science education, where, at Ohio Wesleyan, we have had some specific experience with a grant we received in the first phase of this program, and I think there is no doubt that this particular grant has had a greater impact on our curriculum than any single support we have received over the past decade.

I want to comment just briefly on the subcommittee's draft bill and urge the subcommittee, if at all possible, to increase the overall support in fiscal 1981 of NSF science education programs by \$10 million to \$95.27 million, a 17-percent increase over fiscal 1980 funding, to begin rectification of the long decline of education support within the NSF budget.

This committee has a long record of supporting science education over and above the requested budget and we hope, in this crucial period, you will not fail to set that priority again. Our suggestions on science education programs which could very well use increased funding are included in appendix E.

We also urge that you require that any cuts reflecting current concerns about a balanced Federal budget be administered evenly across all NSF divisions as you have authorized rather than being concentrated on particular parts.

We support the subcommittee's 2-year authorization as contained in its draft bill. We would hope that in years when the subcommittee does not determine new authorizations, it would continue to meet and examine in depth NSF policies.

In view of the House and Senate authorizing committees' significant directives to NSF, for which we are deeply grateful, we hope that you will not deliver the second year budget to NSF unmarked and without comment. Some guidance in your bill indicating either floors of support or proportional shares for program categories would be helpful.

We would like to see also language in the bill to prevent the peremptory scuttling of programs, something NSF has been guilty of in at least two cases this year. For fiscal year 1980, Congress directed the continuation of the science faculty professional development program and the initiation of appropriate technology programs, both of which NSF has attempted to dump in fiscal 1981.

With a 2-year authorization, NSF could be required to give Congress at least 1 year's notice of plans to start up or discontinue programs.

Thank you for this opportunity to present testimony. Thank you. I will be happy to answer any questions that you may have.

[The prepared statement of Dr. Wenzlau follows:]

Statement by

Dr. Thomas E. Wenzlau
President

Ohio Wesleyan University

On the

Fiscal 1981 National Science Foundation Budget Authorizations

On Behalf of

The Great Lakes Colleges Association
and

The Other Members of the Independent Colleges Office,

The American Association of State Colleges and Universities,

and

The National Association of Independent Colleges and Universities

Before the

Subcommittee on Health and Scientific Research

Committee on Labor and Human Resources

U.S. Senate

4232 Dirksen Senate Office Building

March 25, 1980

Senator Metzenbaum and Members of the Subcommittee:

I appreciate very much the opportunity to testify before you today on the National Science Foundation budget request for fiscal 1981. I represent the sixteen independent colleges and universities which share the Independent Colleges Office,* the 338 members of the American Association of State Colleges and Universities, and the 800 members of the National Association of Independent Colleges and Universities. My testimony emphasizes a concern our colleges have expressed to Congress for several years regarding the decreasing real dollar support for science education by the Federal government. We express this concern as educators, as scientists and as citizens.

I wish to make four major points, to support those statements and then to comment specifically about certain items in the proposed NSF budget. The four major points are:

1. Scientific understanding, a direct result of science education, is critical for the progress of our society;
2. Science education and scientific research are mutually interdependent;
3. "Little science" has proven itself historically and offers great potential for future advancement;
4. Resources must be provided to support proven, ongoing science education programs -- tried and true methods of keeping science education current -- as well as to stimulate innovations in science education.

The Importance of Scientific Understanding

Virtually every public policy decision faced by Congress, by legislators at the state level, by city councilmen and by volunteer directors of various organizations requires scientific understanding. Specific issues such as the debates on resource conservation, on fluorocarbons, on solar and nuclear energy,

*The Independent Colleges Office is the Washington Office of the Great Lakes Colleges Association whose members are: Albion College, Antioch University, Denison University, DePauw University, Earlham College, Hope College, Kalamazoo College, Kenyon College, Oberlin College, Ohio Wesleyan University, Wabash College, The College of Wooster. Other Independent Colleges Office members are: Beloit College, Mount Holyoke College, Reed College, Rollins College.

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on DNA synthesis, on environmental pollution, all illustrate the continuing importance of scientific literacy for all citizens.

The need for a scientifically literate general populace means that we must have strong science education programs in our primary and secondary schools and that qualified teachers for those programs must be provided by equally strong science education in our colleges and universities. The most recent National Assessment of Science showed that science achievement of nine-, thirteen- and seventeen-year olds continues to decline, especially in the physical sciences. There the plunge constitutes a crisis. (See Appendix A.) The preparation of research scientists also calls for the very best science teaching from grade school through graduate school. Finally, but not inconsequentially, many undergraduate students who study science will fill jobs in industry and commerce. It is abundantly clear that our ability to deal with the complex issues of the modern world depend greatly on scientific advancement and that our political and economic futures are tied closely to our technical progress.

Interdependence of Science Education and Scientific Research

Congress recognized the interdependence of science education and scientific research when it formed the National Science Foundation. The legislation creating the Foundation charged it "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." (Emphasis added.) Congress throughout has understood that neither can proceed effectively or efficiently without the other. Together they provide the knowledge and manpower both essential to solve specific scientific problems.

We firmly believe that the National Science Foundation has ignored this interrelationship to the point that the low level of support for Science Education

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will have a deleterious effect on the quality of scientific research. At the level of expenditures for Science Education recommended in the National Science Foundation fiscal 1981 budget, real expenditures for Science Education will have declined 83 per cent since 1968. Quite unrealistically this declining level of real expenditures for Science Education is somehow expected to undergird significantly expanded levels of scientific research -- up 78 per cent in real terms since 1968. (See Appendices B and C.)

While we recognize that the nine dollars spent for science education for each ten dollars spent for scientific research in 1968 may be excessive for today's needs, it is equally clear that a ratio which allows for only one dollar of expenditure for science education for each twelve dollars spent for scientific research can only subvert those very research efforts the National Science Foundation seeks to emphasize. Ultimately our national scientific potential must be in jeopardy.

It is critical, we believe, that this Subcommittee recommend to Congress that some reasonable balance be maintained between Science Education and scientific research expenditures. This balance needs to be established even if the overall NSF budget is subjected to cuts in the interest of the national campaign against inflation. In past testimony we have suggested that one dollar for science education should be spent for each three dollars for scientific research expenditures. This ratio of one to three, we believe, will maintain an essential mutually supportive balance between these two vital activities.

The low priority given to Science Education programs by the NSF is further reflected in the uneven (perhaps discriminatory) manner in which the Foundation administers. The Foundation is provided with Program, Development and Management (PDM) funds to cover program evaluation and processing and staff expenditures. NSF appropriately charges PDM funds for peer review panels and other program

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management costs in the research directorates. However, it is not uncommon for the NSF to charge such costs and even certain staff salaries to the program budget when administering Science Education programs. This procedure obviously reduces the funds available to support proposals and is, at best, an arbitrary if not an intentional attempt to promote further the already large imbalance between research program allocations and Science Education program allocations. If we appear piqued, it is only because we are.

These comments should not be construed to be a criticism of the quantity of resources directed to support scientific research. Quite the contrary. We recognize and support basic research expenditures. But those research dollars can be meaningfully used only if a scientific foundation has been prepared by effective science education. This, in turn, requires a reasonable balance between resources allocated to these two interrelated aspects of scientific progress.

The separation of research and science education is not only in the NSF attitude; it is represented by physical distance between the directorates. We continue to believe it to be important for the Science Education Directorate to be moved from the outer edges of the city to the main NSF office. We hope the Subcommittee will order such a move.

We have suggested in previous testimony that a significant amount of resources are absorbed simply in the costs of operating a National Science Board of twenty-four members. We suggest again that this Subcommittee ask the NSF to justify the large number of persons on the Board and the large overhead costs involved. It is our view the NSF could be both more effective and more efficient with a somewhat reduced Board.

"Little Science"

My third major point is related to the significance of what we have chosen to call "little science." Many critical discoveries have originated from "little science" -- carried out by one researcher with modest equipment and an equally modest budget. "Little science" researchers work on college and university

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campuses of all sizes and all over the country. They tend to be concentrated more in some disciplines than in others but possess great and largely untapped potential to make crucial future contributions to new scientific knowledge.

We wish to acknowledge the recognition of the potential of "little science" by this Subcommittee last year in requiring that ten per cent of the research instrumentation grants awarded by NSF be allocated to two- and four-year institutions. This policy, even though modified in Conference, has been extremely beneficial to colleges such as those I represent and, we believe, beneficial to the advancement of scientific knowledge. In its fiscal 1981 budget request, NSF requests \$0.5 million less than the mandated set-aside. In view of NSF's past resistance to Congressional directives, we commend the specific share allocated for this program in the Subcommittee's draft bill.

NSF defines any institution which grants fewer than twenty doctorates in the sciences and social sciences per year as an eligible institution for this program. Nearly one-third (32.6 per cent) of the grants allocated to what the law calls two- and four-year colleges has been awarded to institutions which grant Ph.D. degrees. We believe the language in the Subcommittee's draft bill referring to two- and four-year colleges (page 2, lines 20 through 24) can be strictly observed now that NSF is conducting this program in an open and efficient manner. We commend raising the ceiling cost of such instrumentation to \$35,000, a recognition of inflationary increases.

Innovation and Support

The National Science Foundation mandate concerning science education reads "to initiate and support . . . programs to strengthen scientific research potential and science education programs at all levels" Science Education programs are of two sorts: those which support and sustain the ongoing process of science education and those which respond in some innovative manner to a crisis or new problem. While it may be exciting and certainly more visible

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politically to attack new problems, certain basic needs in science are always with us. Updated curricula and materials with teachers trained to use them are a continuing requisite in elementary and secondary schools. Qualified science faculty and reasonably up to date instructional scientific equipment are needed for good undergraduate science education. These needs are common to all institutions -- large universities, four-year colleges and community colleges.

Among the National Science Foundation support programs which award grants on a competitive basis to help science departments meet continuing needs, I would like to discuss these four: (1) Science Faculty Professional Development, (2) the Instructional Scientific Equipment Program, (3) Undergraduate Research Participation and (4) Comprehensive Assistance to Undergraduate Science Education.

Members of Congress have recognized a tendency within NSF to eliminate support for proven and continuing programs. The preoccupation of the Foundation appears to be one of identifying new problems and devising appropriate programs to respond. This year, for instance, NSF has decided to axe a program of tried and true support for faculty improvement in order to fund another which has not even been tested yet. We urge your continued attention to support of proven programs in science education

Science Faculty Professional Development

The Faculty Fellowships of the Science Faculty Improvement Element ("Science Faculty Professional Development") have suffered because of this propensity of the National Science Foundation to tamper with proven and successful programs. It has provided long-term fellowships to meet an increasingly important need in higher education. The financial pressures impinging upon colleges and universities will make it more difficult for those institutions to provide devices which will make it possible for science faculty members to remain current. Add to that the rapidly expanding base of knowledge in science. The result is a situation in which

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the need for assistance from the National Science Foundation has never been greater.

In spite of this need, last year the National Science Foundation budget eliminated this program altogether. Congress restored it only to have the Foundation give high priority to what it chooses to call the "intensive mode" of faculty improvement through workshops, short courses, seminars, conferences, institutes, etc. The experience of our college and university faculty members is that the fellowship approach which permits the faculty member to become immersed in a different environment, either another academic institution or industry, is far more effective. (See Appendix D.) The extended experience provides the time necessary for adequate absorption and understanding of new knowledge so critical to the intellectual vitality and effectiveness of science faculty members. While the intensive mode approach preferred by the NSF clearly has its value, it is in no sense a substitute for the time extensive processes which have proven their value in the past.

This program is one of the most competitive among those administered by NSF. Fewer than ten per cent of proposals submitted are funded. Thus, it is difficult for us to understand why NSF continues to relegate this approach to faculty improvement to oblivion. We view these science faculty fellowships as a keystone in maintaining quality scientific education in our colleges and recommend funding at \$3.0 million.

Instructional Scientific Equipment Program (ISEP)

We deplore the decrease in funds for the Instructional Scientific Equipment Program (ISEP) that appears in the budget for fiscal 1981. The program is already woefully underfunded; in fiscal 1979 only 19.6 per cent of the applications were funded. Scientific equipment is crucial for effective science education. The ISEP approach, in which the National Science Foundation and the institutions match

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funds, has proven extremely effective in helping institutions meet increasingly
 mostly equipment needs. At the same time, the matching arrangement insures
 that only high priority equipment is acquired.

Consistent with our earlier argument for support funding, this year we urge
 Congress to consider a broadened approach for ISEP grants. Because the replacement
 of outmoded or worn out instructional equipment has become a major problem for
 colleges and universities, we request that Congress augment the funds for ISEP
 and expand the program so that institutions may seek funds for equipment replacement.
 We urge this Subcommittee to increase the funding for ISEP to \$5.0 million.

Undergraduate Research Participation (URP)

Science education must ultimately be judged by its affect on students.
 Thus, we continue also to be perplexed by the reluctance of the National Science
 Foundation to support adequately another program which most directly affects
 students -- the Undergraduate Research Participation program (URP). This
 program illustrates dramatically the interrelatedness of science education and
 scientific research. The fact is that on our campuses scientific research
is science education. URP offers the unique opportunity for small groups
 of talented and motivated undergraduate students to undertake scientific
 research together with the mature faculty researcher, exemplifying the
 learning experience. NSF, although it appears to have increased funds for the
 program, has actually only absorbed another program with a similar goal. We
 urge this Subcommittee to give its support to Undergraduate Research Participation
 by authorizing funds of \$5.0 million.

Comprehensive Assistance to Undergraduate Science Education (CAUSE)

We would also wish to express strong support for the program Comprehensive
 Assistance to Undergraduate Science Education (CAUSE). CAUSE has provoked and has
 supported impressive innovation and development of scientific education programs
 in many colleges throughout the country. My own institution, a recipient in the

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first round of CAUSE grants several years ago, continues to benefit from the stimulation of effort and the resources provided as a result of that grant. Its impact has been more noticeable in its affect on our educational process than any other single grant we have received in the last decade.

The Subcommittee's Draft Bill

In presenting this testimony we have attempted to deal with policy issues rather than merely to detail our specific recommendations with respect to funding levels. Where we have recommended funding levels, we do so on the basis of supporting certain policies for NSF Science Education.

We urge this Subcommittee to increase the overall support in fiscal 1981 of NSF Science Education programs by \$10.0 million to \$95.27 million, a seventeen per cent increase over fiscal 1980 funding, to begin rectification of the long decline of education support within the NSF budget. This Committee has a long record of supporting Science Education over and above the requested budget and we hope in this crucial period you will not fail to set that priority again. Our suggestions on Science Education programs which could very well use increased funding are included in Appendix E.

We also urge that you require that any cuts reflecting current concerns about a balanced Federal budget be administered evenly across all NSF divisions as you have authorized rather than being concentrated on particular parts.

We support the Subcommittee's two-year authorization as contained in its draft bill; we would hope that in years when the Subcommittee does not determine new authorizations, it would continue to meet and examine in depth NSF policies. In view of the House and Senate authorizing committees' significant directives to NSF, for which we are deeply grateful, we hope that you will not deliver the second year budget to NSF unmarked and without comment. Some guidance in your bill indicating either floors of support or proportional shares for program categories would be helpful. We would like to see also language in the bill to prevent the peremptory scuttling

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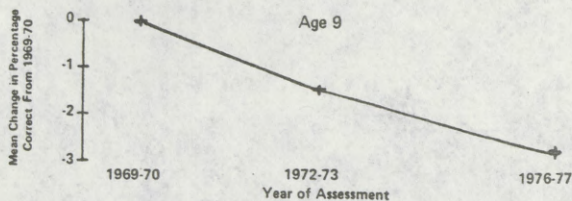
of programs, something NSF has been guilty of in at least two cases this year.

(For fiscal 1980, Congress directed the continuation of the Science Faculty Professional Development program and the initiation of Appropriate Technology programs, both of which NSF has attempted to dump in fiscal 1981.) With a two-year authorization, NSF could be required to give Congress at least one year's notice of plans to start up or discontinue programs.

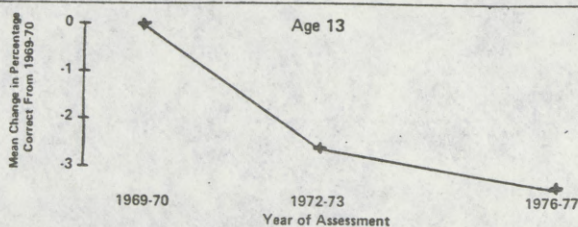
Thank you for this opportunity to present testimony.

APPENDIX A

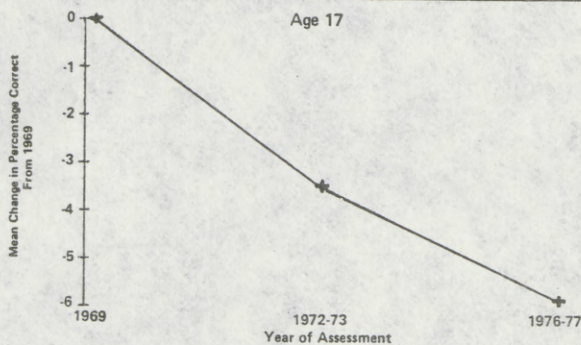
Changes in Physical Science Achievement From 1969-70 to 1972-73
and From 1972-73 to 1976-77 for 9-, 13- and 17-Year-Olds



Mean Change	-1.5	-1.3
Standard Error	.6	.6



Mean Change	-2.6	-.8
Standard Error	.7	.6



Mean Change	-3.5	-2.4
Standard Error	.5	.6

Source: Three National Assessments of Science: Changes in Achievement, 1969-77. National Assessment of Educational Progress, Education Commission of the States. Washington, D.C.: National Center for Education Statistics, June 1978. Exhibit 3, page 8.

APPENDIX B

SUPPORT OF SCIENCE EDUCATION & BASIC RESEARCH^{1/}
 NATIONAL SCIENCE FOUNDATION
 FY 1967-1981 in FY '67 dollars
 (in Millions of dollars)

Fiscal Year	A. Fiscal Calendar Year	B. CPI FY '67 Base=100	C. NSF Budget Expenditure for Science Education	D. Amount Needed to Equal FY 67 Expenditures for Science Ed.	E. Purchasing Power of NSF Sci. Ed. Support in '67 dollars	F. NSF Budget Expenditure for Basic Research	G. Amount Needed to Equal FY 67 Expenditures for Basic Research	H. Purchasing Power of NSF Basic Research Support in '67 dollars
'67	97.2-100.0	98.6	141.7	141.7	141.7	172.6	172.6	172.6
'68	100.0-106.2	102.1	147.6	145.9	143.3	170.6	177.8	175.6
'69	106.2-109.8	107.0	117.4	131.5	107.0	165.9	165.9	165.9
'70	109.8-116.3	113.0	117.4	131.5	93.8	161.0	196.7	161.2
'71	116.3-121.3	118.4	88.2	170.0	73.5	180.3	207.1	150.3
'72	121.3-125.3	123.3	76.0	177.1	59.2	248.6	215.8	198.9
'73	125.3-133.1	129.2	39.9	145.7	30.4	268.6	226.1	204.6
'74	131.1-147.7	140.4	58.1	201.2	40.9	281.0	245.1	197.9
'75	147.7-161.2	154.45	54.7	222.5	34.8	338.1	271.0	215.4
'76	161.2-170.5	165.86	44.3	238.1	26.4	520.9	290.0	310.1
'76 ^{1/2}			2.4	59.5	1.4	128.1	72.5	76.3
'77	170.5-181.5	176.0	46.7	297.6	27.8	649.0	362.5	386.3
'78	181.5-202.9	192.2	56.3	253.6	31.4	472.9	309.0	264.2
'79	202.9-229.9	216.4	59.1	276.3	30.1	601.9	346.0	268.7
'80	229.9-253.8	241.25	61.2	347.2	28.8	679.47	378.8	292.7
'81	253.8-275.6	264.76	66.38	379.8	25.0	679.47	422.9	277.3
					24.7	791.68	462.6	295.3

^{1/}Science Education does not include Graduate Student Support or Traineeships, Technological Innovation in Education and Public Understanding of Science. Basic Research includes Mathematical & Physical Sciences; Astronomical, Atmospheric, Earth & Ocean Sciences; Biological, Behavioral & Social Sciences; Engineering, and the following programs consolidated in "Cross-Directorate Programs," which were previously funded through one or more of the named Directories: Industry/University Cooperative Research, University Research Facilities Improvement, 2-Year/A-Year College Instrumentation, Regional Instrumentation Facilities and Research Initiation in Minority Institutions. (This is done to maintain compatible figures.)

^{2/}CPI=Consumer Price Index (Bureau of Labor Statistics, U.S. Dept. of Labor).

^{3/}Calculated by averaging two adjacent calendar years.

^{4/}Transmutation quarter period from July 1 through September 30, 1977, created by changing Federal Fiscal Year to an October 1 through September 30 basis.

^{5/}Transmutation quarter period from July 1 through September 30, 1977, created by changing Federal Fiscal Year to an October 1 through September 30 basis.

^{6/}Projection based on CPI-keyed 8.6% inflation for FY '81 (CEA, OMB).

^{7/}Current plan.

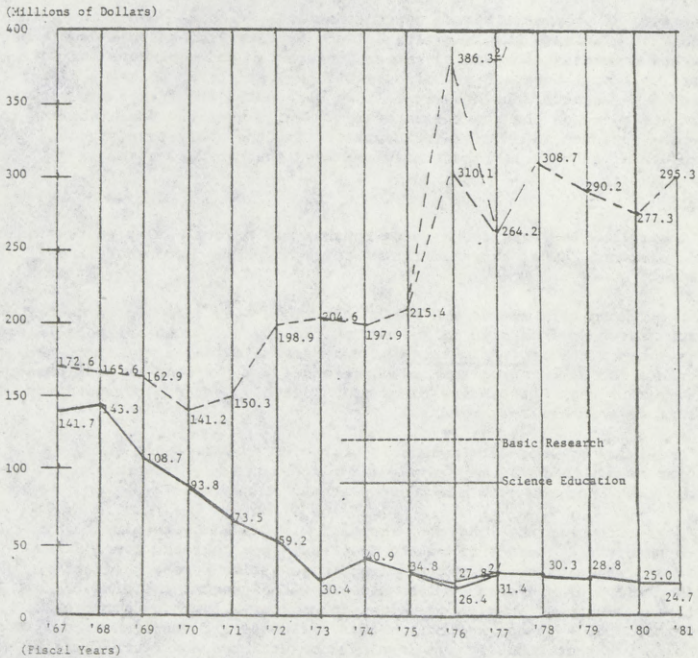
^{8/}NSF Fiscal 1981 budget request.

Sources: NSF Annual Reports for fiscal years 1967 through 1978
 NSF Fiscal 1981 "budget in Brief"
 Revised Consumer Price Index for Urban Wage Earners and Clerical Workers (1967=100), Bureau of Labor Statistics,
 U.S. Department of Labor
 Economic projections of the Council of Economic Advisers,
 Office of Management and Budget

Independent Colleges Office
 February, 1980

APPENDIX C

NATIONAL SCIENCE FOUNDATION
Support of Science Education and Basic Research^{1/}, FY 1967-1981
in FY '67 Dollars



^{1/} Science Education does not include Graduate Student Support or Traineeships, Technological Innovation in Education and Public Understanding of Science. Basic Research includes only Mathematical & Physical Sciences & Engineering; Astronomical, Atmospheric, Earth & Ocean Sciences; and Biological, Behavioral and Social Sciences.

^{2/} Figure includes obligations for transition quarter (July 1 through September 30, 1977) created by changing the Federal Fiscal year to an October 1 through September 30 basis.

Sources: NSF Annual Reports for fiscal years 1967-1977
NSF Fiscal 1980 "Budget in Brief"
Revised Consumer Price Index for Urban Wage Earners and Clerical Workers (1967=100), Bureau of Labor Statistics, U.S. Department of Labor
Economic projections of the Council of Economic Advisers, Office of Management and Budget

Independent Colleges Office
February, 1980

APPENDIX D

VIEWS ON NATIONAL SCIENCE FOUNDATION PROPOSALS
TO EMPHASIZE SHORT-TERM SUMMER AWARDS OVER
LONG-TERM FELLOWSHIP AWARDS FOR
SCIENCE FACULTY DEVELOPMENT

Because of proposals by the current National Science Foundation administration to reduce or eliminate the long-term Science Faculty Professional Development awards and emphasize short-term, summer Conferences and Workshops for College Teachers, all past Independent Colleges Office-Great Lakes Colleges Association-Associated Colleges of the Midwest fellows were asked to offer their views on the long-term versus the short-term awards. While some saw some benefits to a short-term approach, NONE preferred substituting the short-term approach for the long-term, sabbatical opportunity provided through SFPD grants.

Comments

"The fellowship experience /nine months/ was pivotal in my professional development. What happened for me could not have happened in less time."

"... long-term awards are preferable since they allow for a deeper, more extended immersion in subject matter They are more likely to enhance the professionalism of undergraduate teachers. Short-term grants for summer programs and conferences . . . should be supplements to rather than the primary focus of the development of undergraduate science teachers/researchers."

"The value of long-term awards is that you can tailor the study to fit your needs. Many summer grants and conferences are pre-prepared, you take what you get, and much of it may be useless."

"Noteworthy /in the long-term approach/ is the adequate time span to permit the teacher to really "get into" new courses, develop new ideas for teaching and get involved in an active research situation A workshop or conferences does not allow the teacher the time to do these things. A special topic development or a teaching approach methodology -- these are things that workshops and conferences do. There is no way that I could have developed or enriched new courses and developed a new research endeavor in a six-week workshop interval."

"I could not have accomplished my long-range objectives through short-term summer programs. . . . It is extremely difficult to believe that any reasonable number of short summer programs could have served my needs as well as did the intensive 12-month grant period."

"I understand there is some feeling at NSF that the faculty leave support grants . . . be replaced with summer institutes and workshops. I hope that will not come to pass. There is no way I could have accomplished as much in even four full summers. Longer-term leaves cannot be replaced by summer workshops. The two programs serve different goals and will produce different results. And, in my case, the payoffs at Macalester College will be the direct result of my being able to devote an entire year in concentrated preparation."

(Responses from Independent Colleges Office questionnaire, "NSF Science Faculty Professional Development (formerly Science Faculty Fellowship) Program, 1971-1979 ICO-GLCA-ACM Recipients.")

APPENDIX D (continued)

SCIENCE FACULTY PROFESSIONAL DEVELOPMENT PROGRAM
of the National Science Foundation:
AN EVALUATION

Questionnaires were sent to 33 Science Faculty Professional Development Program (SFPD, formerly Science Faculty Fellowships) award recipients in Independent Colleges Office, the Great Lakes Colleges Association and the Associated College of the Midwest member colleges. 40 faculty members had received awards in the period from 1971 through 1979; the program was not funded in 1972 or 1973. Five were no longer with the colleges. Two grantees were out of the country. Of the 21 recipients who responded, one did not complete the questionnaire because he had not accepted the award. The remaining 20 (61 per cent) returned the questionnaires. All 20 used their awards to pursue postdoctoral activities.

Among conclusions drawn from the questionnaires were these:

1. The NSF Science Faculty Professional Development program is the outstanding source of outside support for the continuing education and professional development of our undergraduate college science faculty.

75% of the ICO-GLCA-ACM respondents would not have pursued an identical program of study without NSF support. Instead, many would have adjusted their projects to undertake research elsewhere while others would have cut their leave periods short and spent part of the time teaching on either their own or another college campus.

Comments:

"NSF should terminate any other program and leave SFPD alone."

"The Professional Development award that I got was a wonderful thing for me and for my students. I don't know of a better bargain that the government gets in education for the money. Faculty in small colleges desperately need this program!"

"The fellowship experience was pivotal in my professional development."

"This program is of tremendous humane value, and of tremendous value in the humanization of the science teaching profession, because of its emphasis on the development of the scientist as teacher/person. It must not go!"

"Don't let them destroy this beautiful program!"

"I consider the faculty development program one of the most important in the NSF offerings. It is very difficult for faculty to find time to keep up with modern developments and to implement new ideas into teaching. This program makes it possible."

"These grants are undoubtedly the best possible awards for sabbatical leaves for the small college teacher. They offer course enrichment opportunities as well as the introduction of new courses in the 'rapid pace' scientific curriculum. In addition, the grant recipient has a marvelous opportunity to develop or enrich a research program without the stringent teaching demands that exist during the regular academic session. . . . I strongly resent any effort to alter the SFPD grants by any type of diluted program. This grant is the vital one for upgrading science teaching and research at the college and university level."

SFPD EVALUATION

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2. The Science Faculty Professional Development program is an economical use of government funds, often attracting matching money. It enables college faculty to pursue better programs of personal upgrading than they could otherwise follow by supplementing college sabbatical/leave funds.

75% of ICO-GLCA-ACM recipients requested matching NSF support, usually fifty per cent of the total cost.

3. Student research in past recipients' departments has increased since their return -- even though student research regularly occurs on most ICO-GLCA-ACM campuses during both summer and the academic year. Overall, 65% of the responding recipients were supervising student research when they applied to the Science Faculty Professional Development program, 50% during the academic year and 50% during summer.

60% of responding past fellows reported student research had increased in their departments.

4. In nearly all cases, the Science Faculty Professional Development awardees were conducting their own research when they applied to NSF, part-time during the academic year and usually full-time during summer. Past fellows continue to do so. All but one acknowledge a "significant influence" on the direction or extent of their research by virtue of their SFPD leave experience.

Seventeen past recipients (94%) found the SFPD grant had had a significant influence on their research. Those who elaborated cited new techniques, ideas and direction (72%) and the opportunity to continue to work on projects outside the college and with contacts made as a result of the award tenure (33%). The sole dissenting fellow reported that while his leave activities did not affect his research, they had had an "enormous impact" on his teaching.

Comments:

"My Science Faculty Fellowship allowed me to change my research in a fundamental way . . .".

"This was a major reason for my applying for such a grant. It has enabled me to propose projects to undergraduates . . . which I could never have done without the grant. In addition, I have been able to continue collaboration with some of those in the group with which I worked during my tenure of a Professional Development grant."

"The grant recipient has a marvelous opportunity to develop or enrich a research program without the stringent teaching demands that exist during the regular academic session The NSF award allows them the time to rejuvenate their professionalism generally in an atmosphere where research is a strong ongoing operation and where ideas can be developed and nurtured for return to the home campus."

"I am far more pleased with my research (and teaching) now than I was before the NSF fellowship. It exposed me to research areas I was not equipped to deal with before and made me a better teacher-researcher."

"I discovered new ideas that would have been impossible to find 'at home.' These ideas will influence my teaching of science and my professional career in the future."

SFPD EVALUATION

Page three

"I learned and have applied techniques that I may not have been able to master had it not been for the NSF fellowship."

"I have been a major catalyst in bringing fruitful use of the computer to the entire Lawrence community. I am confident such would never have occurred without my year of self-study."

"The fellowship allowed me to change fields, to an area that I found more appealing and more relevant to my perception of where research efforts would help current needs. In this time of reduced enrollment and tight money, such retooling is more important than ever and harder to bring about than ever. This is one of few fellowships which even remotely permit such a change and is invaluable for that reason."

" . . . new ideas, new techniques and renewed vigor"

"The opportunity to participate full-time with their [University of Minnesota] research group while on my leave opened the door to . . . [a] continuing research opportunity. It is hard to imagine many other mechanisms by which I could have gotten involved in this way."

"Because of my SFPD grant, I have expanded my research activities to more than double of my previous level. My work has [since] been supported by the Research Corporation and the Petroleum Research Fund of the American Chemical Society."

"I am very much better prepared with respect to current techniques used, I have made valuable contacts . . . , and I have been able to write a successful proposal to obtain equipment needed for teaching and research."

5. Almost three-fourths (71%) of the respondents felt their departments required more expertise for a better program (although most felt their departments were already adequate). The need to improve their departments was a factor in their application for an SFPD grant, according to 86% of the respondents.

6. Past fellows in significant numbers related course changes on their campuses to their fellowship:

82 % felt qualified to teach different courses;

30 % of the fellows' departments had added a course or courses;

29 % of the fellows' departments plan to add a course or courses, and

50 % of the fellows thought it likely that new courses would be added.

ALL of the respondents had changed the content of their own course offerings as a result of their fellowship experience.

The impact of the fellowship experience went beyond the fellows' own departments. ALL respondents had participated in new course design or offerings. 63% of those had done so on an inter- or multidisciplinary basis.

Comments:

"The research I did was specifically designed to continue and renew the nuclear physics research program in which my Oberlin undergraduate students participate. Also I had the opportunity to talk to British medical physicists and obtain information which was later incorporated into my general physics course for premedical students. . . . [I have also] developed [a] course on physics of musical instruments."

SFPD EVALUATION

Page four

"My senior-level course in Bioorganic Chemistry is a direct result of my fellowship studies. I have taught it each year since receiving NSF support."

"[I have changed the content of my own course offerings] dramatically. The computer now permeates our curriculum, not just my courses."

"My department consists of only two professors, trying to give a complete major program. . . . I have introduced a new seminar . . . as a direct result. I believe that the courses I teach regularly are very much improved -- new lab exercises, new problem sets, new lectures, better visual aids, etc., I have pioneered in co-teaching various courses with faculty members from nearby colleges."

"The fellowship was for the development of new lab experiments for instruction. The new experiments are now in use in my courses."

"I am currently constructing social science laboratory facilities under a [NSF] CAUSE [Comprehensive Assistance to Undergraduate Science Education; grants to science departments or groups of departments for broad scope improvement in quality and effectiveness of undergraduate science education/ grant. All the ideas for this project came under the tenure of [my] Science Faculty Fellowship."

"Part of my leave activities were directly aimed at permitting me to develop the ability to offer new course materials The grant activities were successful."

7. The science community tends to give its greatest emphasis and support to researchers. Yet teachers of science find a new dimension in their advanced studies by virtue of their teaching experience, according to 93% of our ICO-GLCA-ACM respondents.
8. Past fellows were asked, "Did the Science Faculty Professional Development experience improve your effectiveness as a teacher?" ALL answered "yes," citing new or improved subject matter knowledge (65%) and improved teaching and presentation ideas and style (24%). Almost twenty per cent felt instructional changes they spearheaded as a result of their fellowship affected their institution in a major way.

Comments:

"Frequent up-dating and expansion of our skills is essential! . . . I believe the grant experience . . . greatly improved my effectiveness as a teacher in every way. Even my introductory course, which underwent the least revision, was improved. I feel that the NSF's SFPD grants are a very efficient way to ensure that students at small colleges will get such [the best, most extensive and most sophisticated] coverage even though they must get it from a small number of professors."

"One can only teach what one knows -- and the Fellowships have greatly increased my knowledge -- particularly first hand laboratory experience -- and, of course, [I have] a new, refreshed point of view."

"The students obviously benefit from the stimulated teacher who is now actively pursuing his research and has a grasp of new, up-to-date scientific accomplishment in the field."

SFPD EVALUATION
Page five

"The students tend to sense that I am giving them information based on [field] experience [gained as a result of the fellowship support], and not repeating textbook material, and they pay more attention."

"The experience improved my effectiveness since I gained a much more complete understanding of biochemistry and ancillary areas. . . . particularly because I was able to learn much about recent research and put that into proper perspective. Different teaching styles which were observed during my tenure may also have influenced me. . . ."

" . . . a chance to acquire knowledge and put it in teachable form."

Independent Colleges Office
February, 1980

The Independent Colleges Office is the Washington Office of the Great Lakes Colleges Association whose members are: Albion College, Antioch University, Denison University, Earlham College, Hope College, Kalamazoo College, Kenyon College, Oberlin College, Ohio Wesleyan University, Wabash College, The College of Wooster. Other Independent Colleges Office members are: Beloit College, Mount Holyoke College, Reed College, Rollins College. The Associated Colleges of the Midwest are: Beloit College, Carleton College, Coe College, Colorado College, Cornell College, Grinnell College, Knox College, Lake Forest College, Lawrence University, Macalester College, Monmouth (IL) College, Ripon College, St. Olaf College.

SUMMARY OF BUDGET REQUESTS FOR APPENDIX E
 SELECTED NATIONAL SCIENCE FOUNDATION EDUCATION PROGRAMS
 (In Millions of Dollars)

<u>Program Name</u>	<u>NSF FY 1981</u>		<u>Increase Over</u>		<u>Previous Program</u>
	<u>Request</u>	<u>Our Request</u>	<u>NSF Request</u>	<u>High (Year)</u>	
<u>Comprehensive Assistance to Undergraduate Science Education (CAUSE)</u> Encourages broad scope improvement in quality and effectiveness of undergraduate science education. Maximum \$250,000 award for up to three years in response to detailed plans for a coordinated set of activities for science departments, groups of departments or institution's total science education effort.	13.0	14.0	+1.0	13.8 ('79)	
<u>Instructional Scientific Equipment Program (ISEP)</u> Encourages improvement in undergraduate science education by matching support for purchase of new scientific equipment for educational purposes.	3.0	5.0	+2.0	8.9 ('64)	
<u>Local Course Improvement (LOCI)</u> Funds concentrated, short-term, small-scale efforts by individuals or small groups of faculty to upgrade undergraduate science instruction by redesigning courses in the sciences and social sciences.	3.5	4.2	+0.7	3.0 ('79)	
<u>Science Faculty Professional Development (SFPD)</u> Supports three- to twelve-month research and study projects at institutions of higher education or industrial labs to improve the competence of faculty involved primarily in undergraduate science teaching.	0	3.0	+3.0	predecessors: a. 4.0 ('71) b. 1.3 ('73)	
<u>Student Science Training (SSTP)</u> Provides talented high school students with special advanced courses and/or research participation experience beyond that available in high school for students with high potential from high schools with deficient science training or students with high ability from nationally-recognized, excellent high schools.	3.0	3.3	+0.3	2.5 ('79)	
<u>Pre-College Teacher Development in Science</u> (Teacher Training Programs) Funds academic year or summer programs of continuing education for elementary and secondary school teachers in mathematics, natural or social sciences to upgrade the quality of science teaching.	7.2 ^{1/}	8.2	+1.0	24.3 ('65)	
<u>Undergraduate Research Participation (URP)</u> Provides talented undergraduate students with firsthand experience in scientific research activities through direct collaboration with science faculty.	3.0	5.0	+2.0	6.8 ('66)	

^{1/}Excludes \$2.5 million being requested by the Education Department for projects for teachers in grades K-4.

Independent Colleges Office
March 1980

Basic Research 1980 Investments in the Future

A Joint Statement to the Congress
April 17, 1979

The 40 undersigned organizations and leaders of the nation's universities, colleges, research scientists, and engineers urge the Congress to support the principles of stable, balanced, and controlled investment in federal basic research programs as they are represented in the FY 1980 budget proposals for these programs in the National Science Foundation and in several mission agencies. We also urge Congress to insure funding levels for the research programs of the National Institutes of Health (NIH) consistent with the principles of stable, balanced, and controlled growth. We do so for the following reasons:

The nation's investments in basic research have produced a rich legacy for our country and for the world. The search for knowledge has brought many achievements: the elimination or control of dread diseases, such as poliomyelitis and tuberculosis; improved prevention and treatment of mental and behavioral problems, such as mental retardation and alcoholism; technology of momentous economic and social importance, such as the transistor, the computer, and the laser; discovery of new materials; revolutions in the production of food; and development of the education and advanced training programs that are the very foundation for progress.

In the late 1960's and early 1970's, the nation experienced a long period of decline in real dollars in the level of investment for long-term basic science. In the search for quick solutions to pressing problems, funding policies sought immediate answers at the expense of stable, predictable support for the pursuit of knowledge. Now it is time to renew the nation's commitment to excellence in basic research.

We commend the Administration for proposing a broad strategy designed to produce sustaining and balanced national policies for advancing science and technology. The FY 1980 budget proposals for the National Science Foundation and for several mission agencies are important and necessary steps toward a controlled, coherent investment policy for the nation that would help to regain momentum in the search for new ideas, for new knowledge, and for solutions to the economic, technological, and social problems that confront our society. We need to know more if we are to maintain our economic growth, stimulate productivity, reduce inflation, promote our international competitiveness, protect our environment, meet energy demands, improve health, advance education, and

guarantee national security. We do not currently have the knowledge base to meet these long-range objectives. Sustained national investment in the development of new knowledge and highly trained people is essential if our nation is to retain world leadership in science and technology. There must be balanced, sustained support for fundamental research across all fields of science to meet these challenges.

The basic research budgets for the National Science Foundation, in combination with the ones proposed for many mission agencies, are important starts; but they may barely sustain the nation's research enterprise at current levels. It should be pointed out that a government-wide increase of only about nine percent is proposed for basic research and that inflation has substantially increased since the President's budget was proposed. If the broad investment strategy now proposed by the President is adopted by the Congress and continued and protected in future years, that foundation of new knowledge which the nation needs to meet the challenges of the 1980's and 1990's can be built.

In one critical research agency, the National Institutes of Health (NIH), the budget fails to provide for needed stability. The funding recommendations for NIH research programs would result in cutting in half the number of new basic research awards to university-based and other researchers. Such sharp cuts would terminate promising programs, disrupt the research careers of highly talented young investigators, and discourage others from pursuing such careers. We urge Congress to insure stability for NIH research programs consistent with the government-wide investment strategy of sustained, balanced, and controlled growth.

The effectiveness of federal basic research programs is measured not only by their size, but also by the quality of the tools they provide to researchers and by the effectiveness of agency policies, procedures, and priorities in promoting flexibility, innovation, and the willingness to take risks. The 1980 investment strategy would help stimulate research productivity by beginning to replace and upgrade the aging instrumentation and equipment in our research laboratories.

We also commend the Administration for its commitment to keep research productivity from being further compromised by excessive and unreasonable record keeping and reporting burdens which damage the research environment. We urge the Congress to help insure that administrative requirements are carefully formulated, and simplified wherever possible, so that the fundamental purpose of the federal investment, productive research, is not lost in the pursuit of ever more precise management.

Our national investment strategy must maintain and protect a balanced research structure in which universities, industry, and government all play a part. Government funding and regulatory policies should safeguard the freedom of each sector, encouraging it to perform those roles particularly suited to it. Ways further to improve joint research activities between universities and industry should also be encouraged.

Organizations

American Association for Clinical Chemistry
American Association of Community and Junior Colleges
American Association of State Colleges and Universities
American Association of Dental Research
American Council on Education
American Institute of Biological Sciences
American Physiological Society
American Psychological Association
Associated Colleges of the Midwest
Association for the Advancement of Psychology
Association of American Medical Colleges
Association of American Universities
Association of Catholic Colleges and Universities
Association of Governing Boards
Association of Jesuit Colleges and Universities
Council of Graduate Schools in the United States
Council for Advancement and Support of Education
National Association of Independent Colleges and Universities
National Association of State Universities and Land-Grant Colleges
National Society for Medical Research
Society for Neuroscience

Committees

Board of Public and Scientific Affairs of the American Society for Microbiology
Executive Committee of the Council of Scientific Society Presidents

Officers

Walter E. Blessey, *President*
American Society of Civil Engineers

Truman Botts, *Executive Director*
Conference Board of Mathematical Sciences

Peter B. Boyce, *Executive Officer*
American Astronomical Society

Truman Cook, *President*
National Council of University
Research Administrators

Russell R. Dynes, *Executive Officer*
American Sociological Association

John H. Hammer, *Associate Secretary*
Linguistic Society of America

Eugene L. Hess, *Executive Director*
Federation of American Societies for
Experimental Biology

Mahlon B. Hoagland, M.D., *Spokesman*
Delegation for Basic Biomedical Research

Evron M. Kirkpatrick, *Executive Director*
American Political Science Association

Edward J. Lehman, *Executive Director*
American Anthropological Association

Orval L. Lewis, *President*
American Society of Mechanical Engineers

Joseph J. Martin, *President*
American Society for Engineering Education

Mary E. Rice, *President*
American Society of Zoologists

William J. Russell, *Executive Officer*
American Educational Research Association

John G. Scandallos
Society for Developmental Biology

Robert M. Solow, *President*
American Economic Association

Federico Welsch, *Chairman, Governmental Affairs*
Association of Independent Research Institutes

For information call:

John C. Crowley
Director of Federal Relations for
Science Research
Association of American Universities
(202) 466-5030

Senator SCHWEIKER. Thank you.

Our next witness is Dr. William Klein, director of the Morris Arboretum of the University of Pennsylvania.

I am familiar with Dr. Klein's work because I have worked with science museums to increase funding from the Arts and Humanities Endowments. I also look forward to helping them increase their NSF funding.

Dr. Klein.

Dr. KLEIN. Thank you very much.

It is a pleasure to be here. I appreciate the opportunity to testify today before the Subcommittee on Health and Scientific Research.

I will provide here a summary of my written testimony which will be submitted in full following these hearings.

I am representing the American Association of Botanical Gardens and Arboreta and, science museums in general.

I am the director of the Morris Arboretum of the University of Pennsylvania, a member of the board of the American Association of Botanical Gardens and Arboreta, and the chairman of its finance committee.

There are more than 200 botanical gardens and arboreta in the United States, and almost one-third of these are associated with institutions of higher learning. Each has a unique history; they vary widely in size, diversity of collections; budgets, and in the programs they offer to their varied constituencies. They are science museums and share with other members of the museum community the problems and opportunities of maintaining collections, acquisition, curation, information storage and retrieval, conservation and interpretation.

Botanical gardens and arboreta are devoted to research, to education, and to the exhibition of living collections. They are cultural institutions in every sense of the word. And it is the creative interplay of the various elements of these institutions which makes it possible for them to serve such a wide public today and which endows them with such great promise for the future. It may well be that their multifaceted character is also their undoing. Because they do not fit easily into the usual concept of a museum, they are being denied the kind of support they deserve and can justify on the basis of public demand.

The research activities which go on at these institutions include plant exploration, developing new plants, and the continuing job of testing and evaluating plants for introduction into the nursery trade. We have all witnessed the ravages of the landscape by Dutch elm disease and chestnut blight, and can appreciate the need for the kinds of research that goes on in these institutions. These institutions are also the germ-plasm banks for the rare and endangered plants of the world and the repositories of specimens, documenting work on countless environmental impact statements. As we begin the monumental task of restoring our landscapes, the resources of these institutions are increasingly called into action.

Through their education programs, botanical gardens and arboreta are interpreting the great natural heritage of this country to the public. They are also helping to teach a public, 70 percent of which lives in urban areas, how to keep our cities livable. The relationship between plant and animal life on this planet is one of

complete interdependence. Botanical gardens and arboreta have a major responsibility in making the public more aware of this fundamental fact of life.

As science museums, our institutions are major contributors to the informal educational network that must be mobilized to increase the public's understanding of science. The role of this informal network has been well described by Joel Bloom, director of the Franklin Institute in Philadelphia:

Informal learning begins when we are born and continues throughout our lives. It is the semi-random web of experiences, facts, lessons, impressions, and accumulated knowledge that we continually draw upon. We continually build this matrix in a casual, unstructured and undirected manner from conversations, books, films, broadcasts, newspapers, museum visits and any variety of information sources.

Like all museums, botanical gardens and arboreta have witnessed a great expansion in the demand for their services, and receive about 32 million visitors a year. The number of people has increased in recent years and all of these institutions are suffering from the erosion of their financial base in an inflationary economy. It is absolutely essential that a diversity of Federal funding sources exist if we are to maintain the rich heritage held in all our Nation's museums. And the NSF should be a key element in Federal funding to these institutions.

In this day and age of high technology and rapidly advancing scientific discovery, we cannot afford a scientifically illiterate public. We cannot afford a public that does not understand that we are all a part of a fragile network, a web of interactions that are, as yet, incompletely understood. The long-term consequences of our many assaults on the environment are not known. What we do know, however, is that our very survival depends upon that thin, green mantle of vegetation.

We fully support the expansion in support of biological scientific research by NSF. But it is not enough to push back the frontiers of science. We must develop a scientifically literate public; one that is able to accommodate to this growing addition of scientific information.

Botanical gardens and arboreta provide a diversified approach to public education. They are both cultural institutions and scientific museums. They are reaching a wide audience, and one that is frequently not touched by other cultural institutions. They are struggling to creatively interrelate the scientific way of thinking with a more holistic understanding of the environment. As the public looks for new alternatives in education, the botanical gardens and arboreta of this country are presenting themselves as viable options, model, that should be greatly expanded. But, in order to achieve their potential of public service, they are going to need substantially more and varied kinds of Federal support.

When we look at the patterns of funding—I am distressed, frankly, by what I heard here today when the question was raised about where the heavy cuts in NSF funding would occur. Mr. Atkinson indicated, that heavy cuts would be slated in science education.

That is distressing news indeed in the light of other testimony which you have heard today regarding the decline in scientific literacy of the public. Support of scientific education for the last 10 years has gone from about \$150 million down to about \$50 million.

While NEA and NEH are giving about \$22 million to museum programs—NEA, \$13 million; NEH, \$9 million—NSF is granting a little over \$2 million to museum programs out of a total budget that is a little under \$1 billion. Science education in NSF is up 9 percent over the previous year, but this increase will be wiped out by inflation. Meanwhile, increases of 15 to 25 percent are being sought for basic research.

We would strongly endorse the Honorable George Brown's remarks made at the NSF authorization hearings on February 19: " * * * There is a widening gap in general public understanding of how technology does—or might—affect our world."

Science museums, including botanical gardens and arboreta, with their 160 million visitors a year, are a neglected resource.

Senator SCHWEIKER. Say that again, how many?

Dr. KLEIN. 160 million people a year visitorship. Science museums are a neglected resource; a resource that should be developed by NSF to promote the public understanding of science in the same way that the endowments are developing the artistic and humanistic resources of this Nation. We want to go on record here in support of an increase in funding in the NSF budget for museum programs and science education.

Quoting again from Joel Bloom, a member of the NSF Science Education Advisory Committee:

Someday the child who watches his colored shadows in a science museum will have a flash of insight as he learns about primary colors in school. Someday the person who watches a baby chimp learning sign language on "Nova" will read about government spending for basic research. Investment in informal learning is not an exercise in teaching facts. It is an investment in the richness of our environment and the background of our judgment.

NSF belongs in this arena. It may be the most important contribution it can make to the non-scientist.

I thank you very much for the opportunity to be here.
[The prepared statement of Dr. Klein follows:]

STATEMENT OF DR. WILLIAM KLEIN, DIRECTOR, MORRIS ARBORETUM, UNIVERSITY
OF PENNSYLVANIA

Thank you for this opportunity to testify today before the Subcommittee on Health and Scientific Research and to present the case of the American Association of Botanical Gardens and Arboreta.

I am Bill Klein, Director of the Morris Arboretum of the University of Pennsylvania, a member of the Board of the AABGA, and Chairman of its Finance Committee.

There are more than 200 botanical gardens and arboreta in the United States, and almost one third of these are associated with institutions of higher learning. Each has a unique history; they vary widely in size, diversity of collections, budgets, and in the programs they offer to their varied constituencies. They are science museums and share with other members of the museum community the problems and opportunities of maintaining collections: acquisition, curation, information storage and retrieval, conservation and interpretation.

Botanical gardens and arboreta are devoted to research, to education, and to the exhibition of living collections. They are cultural institutions in every sense of the word. And it is the creative interplay of the various elements of these institutions which makes it possible for them to serve such a wide public today and which endows them with such great promise for the future. It may well be that their multifaceted character is also their undoing. Because they do not fit easily into the usual concept of a museum, they are being denied the kind of support they deserve and can justify on the basis of public demand.

The research activities which go on at these institutions include plant exploration, developing new plants, and the continuing job of testing and evaluating plants for introduction into the nursery trade. We have all witnessed the ravages of the landscape by Dutch elm disease and chestnut blight, and can appreciate the need for the kinds of research that goes on in these institutions. These institutions are also the germ-plasm banks for the rare and endangered plants of the world and the repositories of specimens, documenting work on countless environmental impact statements. As we begin the monumental task of restoring our landscapes, the resources of these institutions are increasingly called into action.

Through their education programs, botanical gardens and arboreta are interpreting the great natural heritage of this country to the public. They are also helping to teach a public, 70 percent of which lives in urban areas, how to keep our cities livable. The relationship between plant and animal life on this planet is one of complete interdependence. Botanical gardens and arboreta have a major responsibility in making the public more aware of this fundamental fact of life.

As science museums, our institutions are major contributors to the informal educational network that must be mobilized to increase the public's understanding of science. The role of this informal network has been well described by Joel Bloom, Director of the Franklin Institute in Philadelphia:

"Informal learning begins when we are born and continues throughout our lives. It is the semi-random web of experiences, facts, lessons, impressions, and accumulated knowledge that we continually draw upon. We continually build this matrix in a casual, unstructured and undirected manner from conversations, books, films, broadcasts, newspapers, museum visits and any variety of information sources."

The living collections in our institutions vary from botanical groupings to floral displays to landscape planting. All combinations can be found. Many of our institutions maintain extensive and, I might add, very expensive conservatories for the public. The arts and the sciences are joined in these places, and the directors of these institutions would be quick to tell anyone that their living collections are maintained primarily for their cultural value and for educational purposes.

Like all museums, botanical gardens and arboreta have witnessed a great expansion in the demand for their services, and receive about 32 million visitors a year. The number of people has increased in recent years and all of these institutions are suffering from the erosion of their financial base in an inflationary economy. It is absolutely essential that a diversity of federal funding sources exist if we are to maintain the rich heritage held in all our nation's museums. And the NSF should be a key element in federal funding to these institutions.

In this day and age of high technology and rapidly advancing scientific discovery, we cannot afford a scientifically illiterate public. We cannot afford a public that does not understand that we are all a part of a fragile network, a web of interactions that are, as yet, incompletely understood. The long-term consequences of our many assaults on the environment are not known. What we do know, however, is that our very survival depends upon that thin, green mantle of vegetation.

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We would strongly endorse the Honorable George Brown's remarks made at the NSF authorization hearings on February 19:

"...there is a widening gap in general public understanding of how technology does -- or might -- affect our world."

Science museums, including botanical gardens and arboreta, with their 160,000,000 visitors a year, are a neglected resource; a resource that should be developed by NSF to promote the public understanding of science in the same way that the Endowments are developing the artistic and humanistic resources of this nation. We want to go on record here in support of an increase in funding in the NSF budget for museum programs and science education.

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"NSF belongs in this arena. It may be the most important contribution it can make to the non-scientist.

William M. Klein, Ph.D.
Chairman,
Financial Planning Committee
AABGA

Senator SCHWEIKER. Thank you.

Let me say that this committee has not sided with the administration on the disproportionate cut going to science education. It is true that a science education rescission from the administration is pending. But this committee in the past has not agreed with science education cuts, so that is obviously a battle that has yet to be fought.

Let me ask Dr. Wenzlau, you made a statement about the comprehensive assistance to undergraduate science education program and its impact has been more noticeable and has affected our educational process more than any other educational grant.

I wonder if you could explain why?

Dr. WENZLAU. This particular proposal we submitted was funded for a computer-oriented program which helped us with providing access for our undergraduates to a new computer that we had acquired at the time of the proposal to NSF. The result has been that we are estimating that approximately one-half of our undergraduates have some exposure to and some knowledge of the way in which computers can help them learn and help to advance their understanding, both of the advantages and I think, equally important, the limitations of computers. This is not limited at all to mathematics courses although our calculus courses taught entirely with a computer orientation. But it is flowing into the social sciences, politics courses, economics courses, ecology courses, biology and science courses, where you would perhaps anticipate this.

It has had a very significant effect on the quality of education at Ohio Wesleyan.

Senator SCHWEIKER. You also touched in your testimony on the 24-member National Science Board.

I wonder if you could explain your concern.

Dr. WENZLAU. This is essentially a concern of expenditures, Senator, and it is always debatable how large a Board one needs to oversee the work of the National Science Foundation. Our concern is simply that Congress ask the National Science Foundation to provide some evidence that a Board of this size and the expenditures undertaken in support of that Board's activities are necessary in order to provide the oversight that that Board is responsible for providing.

We do not have any specific concern other than there is a substantial budget allocation for the support of that activity.

Senator SCHWEIKER. Thank you.

Dr. Pelczar, can you give us any advice on this approach to the budget cutting that we will have to face? I believe Dr. Wenzlau mentioned cutting across the board.

Do you have any particular areas of priority or across the board concept? What suggestions can you give us that might guide us where we have to confront this problem?

Dr. PELCZAR. Senator, that is a very difficult thing for me to do.

Senator SCHWEIKER. It is difficult for us to do, too. But we have to do it somehow.

Dr. Pelczar, I can appreciate that.

As proposed from our vantage point we see that the difficulties that confront society really place a demand on a broader knowledge base which can be then translated into a kind of technology

that would enhance productivity. It is a cyclical phenomenon. We have to continue to build up our encyclopedia of knowledge to be able to deal with the issues that become increasingly more complex almost daily.

On the one hand, you have—you are looking for the young talent that you can provide opportunities for to bring into the system so they can be cultivated to the maximum of their capability. You do not want to lose that tremendous resource. In fact, that is where our strength lies.

I recognize that the barrel has a bottom and that one has to deal within those limitations. But in an overall sense, to provide the opportunity to maximize on the elevation of our knowledge base and a better comprehension of that knowledge base by more individuals that would conceivably produce better options, better decisions that we have made in the past.

I would like to add to a statement that I made earlier. I mentioned that Dr. Ann Reynolds in testimony before this committee earlier urged that the committee consider as an addition to Senate bill 568 a program of national research awards for young women scientists, and she spelled out in some detail what she had in mind. That is what we endorse. We would therefore urge that the subcommittee either provide the additional support to accomplish this or to defer action until the committee considers the bill. I wanted to make that point clear.

Senator SCHWEIKER. We appreciate knowing that because these are some of the hard decisions that we have to face up to. It is helpful to have your input.

Dr. PELCZAR. Those of us that are dealing with these issues, very much like you have to do in your committee, are very much aware of the tremendous difficulties that we are confronted with. But it would appear to us that the investment to advanced knowledge is our best bet for getting out of the difficulties that we are in. It does not appear that a moratorium on the development of new knowledge in any respect will be helpful in working our way to a resolution of issues that confront society at large.

Senator SCHWEIKER. Let me say that I concur, being quite active in not just National Science Foundation authorization but on all basic research programs. If you look at these programs on a return on investment basis, these programs come out high. Unfortunately, some people do not operate under that assumption. One of the reasons we have this funding problem is because of what we call entitlements programs which are the so-called uncontrollable aspects of the budget.

Unfortunately, the high rate of return basic research programs fall under the controllable portion of the budget and therefore get disproportionately more of the axe. I think Congress has to face up to that and define these entitlement programs more clearly, and also not lock them into concrete. The administration, if they go ahead with \$13 to \$20 billion in cuts—could cut anywhere from 10 to 15 percent of the controllable expenditures. Simply because NSF does not have these entitlements they get the brunt of cuts. I think it is unfair and certainly not a good investment for our future.

So your points are well taken. We concur.

It will take a major effort which the Congress has to do if we are going to keep a fair proportion amount of money going into NSF, the National Institutes of Health and others.

We very much apologize for the delay that the witnesses went through this morning because of our scheduling problems. We appreciate your participation.

[Additional material supplied for the record follows:]

*American Association
for the Advancement of Science*

1776 MASSACHUSETTS AVENUE, NW, WASHINGTON, D. C., 20036

Phone: 487-4400 (Area Code 202)

Cable Address: Advancesci, Washington, D. C.

March 26, 1980

The Honorable Edward M. Kennedy
Chairman
Subcommittee on Health and Scientific Research
Labor and Human Resources Committee
U. S. Senate
4230 Dirksen Senate Office Building
Washington, D.C. 20510

Dear Senator Kennedy:

Thank you for inviting the American Association for the Advancement of Science to comment on the Fiscal Year 1981 and 1982 authorization for the National Science Foundation now before your Subcommittee.

As you may know, AAAS, in collaboration with a group of affiliated societies and organizations has for several years prepared a preliminary analysis of the R&D budgets and policies included in the President's budget request. This year's report, entitled Intersociety Preliminary Analysis of R&D in the FY 1981 Budget, was published on 29 February 1980. It includes summaries of the R&D budgets of most of the major R&D agencies, cross-cutting examinations of the R&D budgets for several scientific and engineering disciplines, and a discussion of R&D in colleges and universities. The organizations that participated are listed below.

The objective of this report is to provide independent examinations of the Administration's proposals for support of R&D soon enough after the release of the President's budget so that they can serve as a resource for members of the participating organizations and other persons in government, industry, and academia who are involved in the Congressional budget process.

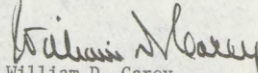
I am enclosing several excerpts from the report particularly relevant to the NSF budget which might be printed as part of the hearing record. These include the "Overview;" "R&D in the National Science Foundation, FY 1981;" and, as example of a disciplinary analysis, "Chemistry in the FY 1981 Budget." For the Subcommittee's information, a complete copy of the report is also included. Please feel free to incorporate additional sections in the hearing record should you see fit to do so.

The Honorable Edward M. Kennedy
 March 26, 1980
 Page 2

The Subcommittee might also be interested in related activities and reports concerning the R&D budget. A summary of the impacts of the FY 1981 budget for higher education was published in early February by a group of Washington based associations and higher education institutions, including Association of American Universities and National Association of State Universities and Land-Grant Colleges. Research and Development: AAAS Report V, to be published by AAAS in early June, will provide a thorough analysis of the treatment of R&D in the FY 1981 budget and will also include consideration of the budget process, scientific research funding at Universities, industry R&D and the economy, selected international aspects of R&D, and state and local interests in R&D. Finally, in the fall, the intersociety group will prepare a report on Congressional action on R&D in the FY 1981 budget.

On behalf of the organizations that contributed to the Intersociety Preliminary Analysis, we at AAAS would like to express our appreciation for this opportunity to be of service to the Subcommittee. If we can be of further assistance, please do not hesitate to call upon us.

Sincerely,


 William D. Carey
 Executive Officer

WDC:11
 Encs.

Organizations participating in the Intersociety Preliminary Analysis of R&D in the FY 1981 Budget:

American Association for the Advancement of Science	American Physical Society
American Anthropological Association	American Psychological Association
American Chemical Society	American Society of Mechanical Engineers
American Educational Research Association	Association of American Universities
American Institute of Aeronautics and Astronautics	Conference Board of Mathematical Sciences
American Institute of Biological Sciences	Council of Graduate Schools
American Institute of Chemical Engineers	Institute of Electrical and Electronics Engineers
American Meteorological Society	National Association of State Universities and Land-Grant Colleges

Intersociety Preliminary Analyses of R&D In the FY 1981 Budget

American Association for the
Advancement of Science

American Anthropological Association

American Chemical Society

American Educational Research
Association

American Institute of Aeronautics
and Astronautics

American Institute of Biological Sciences

American Institute of Chemical Engineers

American Meteorological Society

American Physical Society

American Psychological Association

American Society of Mechanical Engineers

Association of American Universities

Conference Board of Mathematical
Sciences

Council of Graduate Schools

Institute of Electrical and
Electronics Engineers

National Association of State
Universities and Land-Grant Colleges

February 1980

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FOREWORD

These papers summarize and to some extent analyze the R&D budgets and policies included in the President's FY 1981 budget. The objective is to provide independent examinations of the Administration's proposals for support of R&D soon enough after the release of the President's budget so that they can serve as a resource for members of the participating organizations and other persons in government, industry, and academia who are involved in the congressional budget process.

This intersociety project began in 1978 when seven societies cooperated in the preparation of a report analogous to this one on support for R&D in the President's FY 1979 budget and a follow-up report in the fall that summarized congressional actions on the President's recommendations for R&D. Now in its third year, the project currently involves the participation of sixteen cooperating societies in the preparation of these reports. With a larger group, more comprehensive coverage of the major R&D agencies is possible (the Department of Defense is omitted because of lack of sufficient information at the time the report goes to press), and additional disciplinary summaries are included as well.

The document is not comprehensive; the analyses do not include all the relevant agencies and subject areas. Each participating society has reviewed, to the extent possible within the limits of time, staff, and information available, those R&D budgets of greatest interest to its members. Individual societies should be contacted directly for additional analyses that they may have prepared since the publication of this report.

Two other reports also may be of interest. A summary of the impacts of the FY 1981 budget for higher education was published in early February by a group of Washington-based associations and higher education institutions, including AAU and NASULGC. Research and Development: AAAS Report V, to be published by AAAS in early June, will provide a thorough analysis of the treatment of R&D in the FY 1981 budget and will also include consideration of the budget process, scientific research funding at universities, industry R&D and the economy, selected international aspects of R&D, and state and local interests in R&D.

The intersociety project on R&D budgets continues to look for the most effective ways to provide information in a timely manner to decision-makers in government and members of the scientific, higher educational, and engineering communities. The cooperating organizations would appreciate reactions to this document and suggestions on how to proceed in the future; these may be given to any of the persons listed below.

American Association for the Advancement of Science: Gail J. Breslow; Albert H. Teich
 American Anthropological Association: Louis Cimino
 American Chemical Society: Nhung McLeland
 American Educational Research Association: David Florio
 American Institute of Aeronautics and Astronautics: Johan Benson
 American Institute of Biological Sciences: Arthur Gentile
 American Institute of Chemical Engineers: J. R. Hightower
 American Meteorological Society: Ken Spengler
 American Physical Society: Peter Parker
 American Psychological Association: Virginia Holt
 American Society of Mechanical Engineers: Bernard Fishman; C. J. Sullivan
 Association of American Universities: John C. Crowley
 Conference Board of the Mathematical Sciences: Truman Botts
 Council of Graduate Schools: Andrea W. Bolling; Michael J. Pelczar, Jr.
 Institute of Electrical and Electronics Engineers: William Herrold
 National Association of State Universities and Land-Grant Colleges: Jerold Roschwalb

OVERVIEW OF R&D IN THE FY 1981 BUDGET

*American Association for the Advancement of Science
Gail J. Breslow*

Research and development in the federal budget is carried in the separate budgets of the many executive departments and agencies that engage in R&D. The total amount for R&D in the federal budget each year is the resultant of a large number of separate, specific budget decisions in which the requirements for R&D are related to the missions and programs of each department and agency.

This chapter first describes the policies affecting R&D set forth by the President and his top science officials, then presents statistical summaries of support for R&D that are useful for understanding the general composition of federal R&D and the major funding trends. The succeeding chapters provide statistics and analyses of R&D budgets and policies in selected agencies and disciplines. The figures in the subsequent chapters do not necessarily correspond directly to the overall statistics in this chapter because R&D frequently is not managed or budgeted by the agencies in the same categories used in the statistical summaries.

The available data on the totals for R&D in the federal budget come from the compilation of amounts for R&D in the individual agency budgets prepared each year by the Office of Management and Budget (OMB) and published in a "Special Analysis of Federal Research and Development" ("Special Analysis K" in the FY 1981 budget), along with the President's budget. In April the Division of Science Resources Studies of the National Science Foundation (NSF) publishes a report on R&D funding by budget function for the current budget years; later in the year NSF publishes reports on R&D that also include historical data.¹

R&D Policies

The major lines of President Carter's R&D policies were established with the submission to Congress of the FY 1979 budget recommendation, the first to be developed fully by the Carter Administration. Since that time the President's policy pronouncements on R&D have expanded upon and reaffirmed these themes. The policies on which the decisions on R&D in the FY 1981 budget are based are no exception. The FY 1981 budget is consistent with Carter's R&D policies as set forth in prior-year budgets and policy statements, most recently in the President's March 1979 special message to Congress on science and technology. The policies include:

- continued government-wide real growth in the funding of basic research;
- attention to R&D to meet direct federal responsibilities where the primary user is the government itself (as in the areas of national defense and space technology);
- investment in R&D efforts addressing economic and social needs where there are insufficient incentives for the private sector to invest enough in the national interest, but not in efforts where there are near-term commercial payoffs and where the private sector has a clear responsibility.

¹ A full discussion of federal budgeting for R&D is contained in the first AAAS budget report (Willis H. Shapley, Research and Development in the Federal Budget: FY 1977). Further aspects are discussed in the three subsequent AAAS reports (Willis H. Shapley, Don I. Phillips, and Herbert Roback, Research and Development in the Federal Budget: FY 1978; Willis H. Shapley and Don I. Phillips, Research and Development: AAAS Report III; and Willis H. Shapley and Don I. Phillips, Research and Development: AAAS Report IV). All publications are available from AAAS.

In this year's budget documents, considerable attention is given to the basic research efforts in which the federal government is engaged, both through the National Science Foundation and in the various mission agencies. The Budget and State of the Union Messages make note of the importance of the investment in basic research and its long-term payoffs in terms of new industries, increased employment, and general revitalization of the economy. An account of how basic research has fared in the Carter Administration is contained in a special section of the Special Analyses of the Budget on "Major Accomplishments." This section provides an election-year look at some of the areas that have been the focus of government efforts in the Carter Administration, including the environment, energy, health, national security, and science and technology.

Although most of the attention and rhetoric in the budget documents is devoted to funding for basic research, applied research and development increase substantially as well this year, mainly as a result of the President's pledge to boost the defense budget well beyond the expected rate of inflation, in light of the current world situation.

As a result of the Administration's efforts to hold down the deficit in a budget it has described as "prudent and responsible" and "restrained," there are few new major initiatives in R&D proposed in this year's budget. In keeping with the President's pronouncements on industrial innovation in October 1979, however, several small-budget initiatives are proposed for FY 1981. The Department of Commerce and NSF will share \$50 million in new funds to facilitate innovation and encourage productivity. A cooperative automotive research program between the government and the automotive industry will get on the road with initial federal funding of \$20 million. In addition to the industrial innovation projects, another initiative with joint government/industry support will launch NSF and several oil companies on a ten-year ocean margin drilling program, with \$10 million in NSF's budget for initial federal funding. Consideration of tax breaks to encourage industrial innovation was deferred last fall pending decisions on the fiscal policies to be set forth in this year's budget. The decision, however, was to recommend no tax cuts in the budget, although the Administration has left room for a change in policy should economic conditions alter substantially in the months ahead.

In an effort to improve coordination and ensure more effective overall use of federal R&D dollars, interagency projects have been receiving increased emphasis in recent years. This trend will continue in FY 1981, with a number of projects crossing agency lines. These include programs such as a National Oceanic Satellite System (NOSS) to be developed jointly by NASA, the Department of Defense, and the National Oceanographic and Atmospheric Administration (NOAA); an expanded assessment of the value of space remote sensing data (dubbed AgriSTARS) to be conducted by five mission agencies; and a strengthened program in microelectronics and submicron science begun in FY 1979 and shared by DOD, NSF, and the National Bureau of Standards (NBS).

In general, the R&D budget policies set forth in the FY 1981 recommendations are in keeping with those in previous Carter budgets. Consistent support for basic research and a continued policy of limiting federal involvement in the support of private sector development and demonstration projects (with the exception of certain energy-related activities) provide for relatively little dramatic change in this year's budget. Indeed, the most noteworthy characteristic of the FY 1981 budget may well be the fact that the Administration's R&D budget policies have survived relatively intact through another year of general fiscal austerity.

Budget Statistics

A few comments on R&D budget statistics are in order before examining the totals and trends for support of R&D in the FY 1981 budget.

Budget statistics are presented on three bases: (1) budget authority, corresponding to the funds appropriated each year; (2) obligations, indicating the amounts of contracts and grants entered into; and (3) outlays, representing the amounts actually expended. Because budget decisions in the Executive Branch and in Congress are almost always made in budget authority, this basis most accurately reflects current changes in budget policies. Outlay trends lag a year or more behind decisions in budget authority, and obligations estimates are often adjusted to meet fiscal or budget strategy demands. We have,

therefore, selected budget authority as the most meaningful measure of budget decisions and trends and used it in nearly all cases in this chapter and throughout the report.

The allocation of agency budgets among basic research, applied research, and development is not an exact procedure; a certain arbitrariness is inevitably involved. The severe time pressures under which these figures are compiled for "Special Analysis K" also are a problem. Nevertheless, there is presumably consistency within each agency's estimates so that the trends are meaningful.

In the FY 1980 budget the National Institutes of Health (NIH) changed the basis on which it allocates funds to each of the three R&D categories. This change, which is part of the Institutes' continuing effort to develop a useful model for budget formulation and presentation, has resulted in an increase in the portion of the NIH budget classified as basic research. The NIH totals for the three years in the budget--FY 1979, 1980, and 1981--have been classified on the new basis; comparable totals for FY 1967 and 1972 have been estimated on the basis of conversations with NIH officials.

Two general notes pertain to the data in this chapter:

- Due to rounding in the tables, the detail may not add to the totals and the percentage changes may not correspond exactly to the differences shown.
- The conversions of the data on R&D budgets to constant FY 1972 dollars have been made by the authors using OMB fiscal year deflators for federal expenditures for goods and services, which assume an estimated inflation rate of approximately 8.4% between FY 1979 and FY 1980 and 8.1% between FY 1980 and FY 1981.

Statistical Overview

Tables 1-3 show the totals for federal funding for R&D, for conduct of R&D by character of work, and for major R&D functions, respectively.

Table 1. Total Federal Funding for R&D (in billions)

	FY 1967 ¹ Actual	FY 1972 ¹ Actual	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget
Current dollars:					
Conduct of R&D					
Budget Authority	\$16.5	\$16.5	\$28.9	\$31.8	\$36.3
Obligations	16.5	16.5	28.9	32.0	36.1
Outlays	16.1	16.2	26.6	30.5	33.7
R&D Facilities					
Budget Authority	0.6	0.6	1.5	1.7	2.0
Obligations	0.6	0.6	1.4	2.0	2.0
Outlays	0.8	0.6	1.3	1.7	1.9
Total R&D					
Budget Authority	17.1	17.1	30.5	33.5	38.3
Obligations	17.1	17.1	30.3	34.0	38.1
Outlays	16.9	16.7	27.8	32.2	35.6
Constant FY 1972 Dollars (Budget Authority only)					
Conduct of R&D	\$22.3	\$16.5	\$17.1	\$17.3	\$18.3
R&D Facilities	0.8	0.6	0.9	0.9	1.0
Total R&D	\$23.1	\$17.1	\$18.0	\$18.2	\$19.3

Source: "OMB Data for Special Analysis K" and Federal Funds, Volume XXV, NSF. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

¹Authors' estimates based on above sources.

In budget authority, the tables show that:

- Total budget authority for R&D increases at a faster pace than the assumed rate of inflation in FY 1981; in constant dollars, the boost for total R&D is 5.7% over the FY 1980 level (using the unrounded amounts).
- Basic research budget authority receives an 11.5% increase in current dollars. Although Table 2 implies level funding from FY 1980 in constant dollars, this is an artifact due to rounding; in fact, basic research is slated for a 3.5% real increase over FY 1980, as will be seen in Table 5.
- Increases for R&D in the FY 1981 budget are not limited to basic research. In contrast to the very slow growth of applied research and development in the past several years, substantial increases are proposed for FY 1981. In fact, applied research and development increase at higher rates than does basic research, receiving real increases of 3.6% and 6.7%, respectively, in budget authority.
- The major R&D functions increase across the board in current dollars in FY 1981, as indicated in Table 3. In constant dollars, however, Defense is the only area of R&D to show an increase over FY 1980 (12.5%, using the unrounded amounts). In fact, Defense R&D, which decreased in constant dollars between FY 1972 and FY 1979, is on its way back up--surpassing its FY 1972 level of \$9.2 billion. In contrast, Energy R&D, which grew four-fold between FY 1972 and FY 1978, has barely held its own since then in real terms. As shown in Table 3, Health R&D is slated for a small decrease in constant dollars. The cut is smaller than in previous years, however, because of the Administration's desire to avoid congressional "manipulation" of the NIH budget by breaking with tradition and recommending a small current dollar increase for the Institutes.

Table 2. Conduct of R&D by Character of Work (Budget Authority in billions)

	FY 1967 ¹ Actual	FY 1972 ¹ Actual	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget
Current dollars:					
Basic Research	\$ 1.8	\$ 2.1	\$ 4.1	\$ 4.5	\$ 5.1
Applied Research	2.9	3.7	6.7	7.4	8.3
Total Research	\$ 4.7	\$ 5.8	\$10.8	\$12.0	\$13.4
Development	11.8	10.7	18.1	19.9	22.9
Total Conduct of R&D	\$16.5	\$16.5	\$28.9	\$31.8	\$36.3
Constant FY 1972 dollars:					
Basic Research	\$ 2.4	\$ 2.1	\$ 2.4	\$ 2.5	\$ 2.5
Applied Research	3.9	3.7	3.9	4.0	4.2
Total Research	\$ 6.3	\$ 5.8	\$ 6.4	\$ 6.5	\$ 6.7
Development	15.9	10.7	10.7	10.8	11.5
Total Conduct of R&D	\$22.3	\$16.5	\$17.1	\$17.3	\$18.3

Source: "OMB Data for Special Analysis K" and Federal Funds, Volumes XXV and XXVII. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

¹Authors' estimates based on above sources. Estimates reflect the change in the classification of R&D in NIH.

Table 3. Major Components of Federal Funding for R&D*
(Budget Authority in billions)

	FY 1967 Actual	FY 1972 Actual	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget
Current dollars:					
Defense ¹	\$ 8.8	\$ 9.2	\$14.3	\$15.6	\$18.9
Space ²	4.7	2.7	3.9	4.6	5.0
Civilian ³	(3.6)	(5.2)	(12.2)	(13.3)	(14.4)
Health ⁴	1.3	2.0	3.8	4.2	4.4
Energy ⁵	0.6	0.6	3.9	4.3	4.6
General Science ⁶	0.5	0.7	1.3	1.4	1.6
All Other	1.2	1.9	3.2	3.5	3.9
Total R&D	\$17.1	\$17.1	\$30.5	\$33.5	\$38.3
Constant FY 1972 dollars:					
Defense	\$11.9	\$ 9.2	\$ 8.4	\$ 8.5	\$ 9.5
Space	6.3	2.7	2.3	2.5	2.5
Civilian	(4.9)	(5.2)	(7.2)	(7.2)	(7.3)
Health	1.8	2.0	2.3	2.3	2.2
Energy	0.8	0.6	2.3	2.3	2.3
General Science	0.7	0.7	0.7	0.8	0.8
All Other	1.6	1.9	1.9	1.9	1.9
Total R&D	\$23.1	\$17.1	\$18.0	\$18.2	\$19.3

Source: Authors' estimates based on data from Office of Management and Budget; "OMB Data for Special Analysis K;" Federal Funds, Volumes XXV and XXVII, NSF; An Analysis of Federal R&D Funding by Function, FY 1969-1978, NSF. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

*Includes conduct of R&D and R&D facilities.

¹Includes DOD and defense activities in DOE.

²Includes NASA minus space applications and aeronautical research.

³Includes all R&D not in Defense and Space.

⁴Based on data from OMB on health research in all federal agencies. Excludes health research in DOD, DOE, NASA, and NSF.

⁵Includes DOE, Nuclear Regulatory Commission, and energy research in EPA; defense activities and general science in DOE are excluded.

⁶Includes NSF and general science in DOE. Does not include mission-oriented general science.

Relation of R&D to Total Budget and Gross National Product (GNP)

Tables 4-a and 4-b show outlays for R&D in relation to the total budget and the GNP, as estimated in the FY 1981 budget.

As the tables indicate, two-thirds of the total budget goes for payments for individuals, grants to states and localities, interest, and other financial transactions. Another 20% is for national defense, exclusive of R&D. Of the remainder, over 40% goes for R&D, divided about equally in FY 1981 between national defense R&D (\$18.0 billion) and non-defense R&D (\$17.6 billion). National defense R&D outlays are about 12% of total national defense outlays. Non-defense R&D represents about 28% of non-defense "all other" outlays. These percentages indicate the degree to which discretionary outlays in the federal budget have been committed to R&D.

Table 4-a. Total Budget, Federal R&D, and GNP in Current Dollars (in billions)

	FY 1967 <u>Actual</u>	FY 1972 <u>Actual</u>	FY 1979 <u>Actual</u>	FY 1980 <u>Est.</u>	FY 1981 <u>Budget</u>
OUTLAYS					
Research & Development:					
Basic Research	\$ 1.6	\$ 1.9	\$ 3.7	\$ 4.2	\$ 4.7
Applied Research	2.9	3.7	6.2	6.8	7.6
Development	11.6	10.5	16.7	19.5	21.4
Total Conduct of R&D	\$16.1	\$16.2	\$26.6	\$30.5	\$33.7
R&D Facilities	\$ 0.8	\$ 0.6	\$ 1.2	\$ 1.7	\$ 1.9
Total R&D Outlays	\$16.9	\$16.7	\$27.8	\$32.2	\$35.6
National Defense ¹	\$ 59.9	\$ 67.5	\$104.3	\$114.7	\$128.3
Payments & Grants ²	53.2	110.6	281.4	321.4	361.0
Net Interest	10.3	15.5	42.6	51.8	54.2
Other Financial (net) ³	18.0	21.7	-0.3	+1.7	-8.5
All Other			37.9	41.8	45.2
Total Budget Outlays	\$158.3	\$232.0	\$493.7	\$563.6	\$615.8
TOTAL GNP	\$774.4	\$1,110.5	\$2,368.5	\$2,567.0	\$2,842.0
Total R&D Outlays					
As Percent of Total Outlays	10.65%	7.22%	5.63%	5.71%	5.78%
As Percent of GNP	2.17%	1.51%	1.17%	1.25%	1.25%
Basic Research Outlays:					
As Percent of Total Outlays	1.02%	0.84%	0.76%	0.74%	0.76%
As Percent of GNP	0.21%	0.17%	0.16%	0.16%	0.16%

Source: AAAS estimates based on OMB data for Table 22 and "Special Analysis K" in the FY 1981 Budget; R&D data for FY 1967 and FY 1972 from NSF Federal Funds series.

¹Excluding R&D.

²Payments for individuals and grants to states and localities, excluding R&D.

³Major federal financial programs and offsetting receipts.

Table 4-a shows that the FY 1981 budget projects a continuing increase in R&D outlays as a percentage of total budget outlays: from 5.63% in FY 1979 to 5.71% in FY 1980 and 5.78% in FY 1981. The corresponding percentages for basic research show a more level pattern averaging about 0.75% for the three years. However, if the Administration's generally optimistic economic assumptions are not realized and anti-recession or recession-driven outlays are increased, these R&D percentages would fall. In terms of percent of GNP, total R&D and basic research are holding steady at 1.25% and 0.16%, respectively, under the Administration's economic projections.

In constant dollar terms, as shown in Table 4-b, total budget outlays in the FY 1981 budget would be essentially level under the inflation rate assumptions used by the Administration. Within this total, R&D outlays show a "real" growth of 2.5% overall and of 3.4% for basic research. This compares to "real" growths of 3.2% for national defense (exclusive of R&D) and 2.3% for payments and grants and contrasts to a projected decline in financial-type transactions (farm subsidies, mortgage insurance, etc.) and zero "real" growth in the "all other" category. These figures support the conclusion that R&D was well treated in the FY budget.

Table 4-b. Total Budget and Federal R&D in Constant FY 1972 Dollars (in billions)

	FY 1967 Actual	FY 1972 Actual	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget
OUTLAYS					
Basic Research	\$ 2.2	\$ 1.9	\$ 2.2	\$ 2.3	\$ 2.4
Applied Research	3.9	3.7	3.6	3.7	3.8
Development	15.6	10.5	9.8	10.6	10.8
Total Conduct of R&D	\$21.7	\$16.2	\$15.7	\$16.6	\$17.0
R&D Facilities	\$ 1.1	\$ 0.6	\$ 0.7	\$ 0.9	\$ 1.0
Total R&D Outlays	\$21.8	\$16.7	\$16.4	\$17.5	\$17.9
National Defense	\$ 80.8	\$ 67.5	\$ 61.4	\$ 62.2	\$ 64.2
Payments & Grants	67.9	110.6	163.0	166.6	170.9
Net Interest	16.1	15.5	17.0	16.3	15.3
Other Financial (net)	{ 24.2	21.7}	-0.2	+0.9	-4.3
All Other			22.4	22.8	22.8
Total Budget Outlays	\$211.8	\$232.0	\$280.0	\$286.3	\$286.8

Source: Table 4-a above. Conversion to constant FY 1972 dollars based on OMB factors for Table 22, FY 1981 Budget.

Basic Research and R&D at Colleges and Universities

The detail by agency in the support for basic research is shown in Table 5. Total basic research is slated for an increase from FY 1980 of 3.5% in constant dollars, continuing the real growth that began in FY 1975 and reflecting the Administration's consistent policy of providing for support of basic research, even in generally lean budget years. As noted in the "Major Accomplishments" section in the Special Analyses volume of the FY 1981 Budget, federal support for basic research has increased by approximately 9% in constant dollars since FY 1978.

As indicated in Table 5, the Administration proposes that \$5.1 billion be spent for basic research in FY 1981, up from \$4.5 billion in FY 1980. (In addition to the funds shown in Table 5, the federal government also supports basic research by providing funds for the construction of research facilities through agencies such as DOE, NASA, NSF, and DOD. These amounts are not reflected in the table.) The increase in total basic research is reflected not only in the NSF budget request (up 8.1% in constant dollars) but also in several of the mission agencies, with the largest increases proposed for the Departments of Commerce and Education and for the Environmental Protection Agency. In addition, the overall increase in the Department of Defense's FY 1981 budget is reflected in its basic research component; DOD receives a substantial increase of 11.7% in constant dollars. The need to strengthen basic research in specific areas of national concern and government responsibility is cited in "Special Analysis K" by way of explanation. Special emphasis is also being given to strengthening basic research in NSF and the mission agencies for the physical sciences and engineering, which the Administration points out have lagged behind other fields of science in growth for basic research. Although NIH supports more basic research than any other federal agency, it does not share in the Carter Administration's real-dollar boost for basic research. NIH is slated for a 1.8% decrease from FY 1980 in constant dollars, although the Administration is quick to point out that NIH basic research funding has increased by 44% in actual dollars since FY 1978, a rate higher than the average across all federal agencies.

Table 5. Conduct of Basic Research by Agency in Current and Constant FY 1972 Dollars (Budget Authority in millions)¹

	FY 1967 ² Actual	FY 1972 ² Actual	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget	% Change FY 1980 to 1981 in Constant Dollars
NIH	\$ 385 (519)	\$ 546 (546)	\$1,463 (863)	\$1,604 (872)	\$1,704 (857)	- 1.8%
Other HHS ³	63 (85)	80 (80)	117 (69)	121 (66)	128 (64)	- 2.2%
NSF	239 (322)	368 (368)	733 (432)	814 (443)	952 (479)	+ 8.1%
Energy ⁴	302 (407)	268 (268)	465 (274)	522 (284)	592 (298)	+ 4.9%
NASA	328 (442)	332 (332)	513 (303)	538 (293)	581 (292)	- 0.1%
Defense-Military	284 (383)	270 (270)	365 (215)	441 (240)	533 (268)	+11.7%
Agriculture	100 (135)	137 (137)	255 (150)	278 (151)	315 (158)	+ 4.7%
Interior ⁵	--	--	75 (44)	76 (41)	78 (39)	- 4.1%
Smithsonian ⁵	--	--	37 (22)	39 (21)	45 (22)	+ 4.9%
Commerce ⁵	--	--	25 (15)	29 (16)	38 (19)	+21.2%
Education	--	--	20 (12)	20 (11)	25 (13)	+18.3%
Automotive Basic Research	--	--	--	--	20 (10)	--
EPA	--	--	10 (6)	14 (8)	19 (9)	+19.9%
Other	103 (139)	138 (138)	30 (18)	32 (17)	38 (19)	+12.0%
Total Basic Research Current Dollars	\$1,804	\$2,139	\$4,108	\$4,527	\$5,068	
Constant FY 1972 Dollars	(2,434)	(2,139)	(2,424)	(2,463)	(2,549)	+ 3.5%

Source: "OMB Data for Special Analysis K" and Federal Funds, Volumes XXV and XXVII.

Conversion to constant FY 1972 dollars by authors based on OMB deflators.

¹Constant FY 1972 dollars are shown in parentheses.

²Authors' estimates based on above sources. NIH estimates are comparable with the classification of R&D in NIH used in the FY 1981 budget.

³For FY 1967 and 1972, data include Education.

⁴For FY 1967 and 1972, data are reported under the Atomic Energy Commission.

⁵For FY 1967 and 1972, this agency is included in "Other."

Colleges and universities are the primary performers of basic research for both the federal government and the nation as a whole. The budget materials do not contain data on the amount of basic research funds going to this sector, but they do provide estimates of total funds for R&D expected to go to colleges and universities, as shown in Table 6. Total R&D funds to colleges and universities are expected to increase by 1.3% in constant dollars, although substantial additions to the figures shown for the DOD academic science program are anticipated which would raise the DOD increase from FY 1980 from 2% as shown here to approximately 15% in real terms. This, in turn, would raise the total R&D increase by several percentage points.

Table 6. Support for Conduct of R&D at Colleges and Universities in Current and Constant FY 1972 Dollars¹ (Budget Authority in millions)

	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget	% Change FY 1980 to 1981 in Constant Dollars
NIH	\$1,771 (1,045)	\$1,929 (1,049)	\$2,057 (1,035)	- 1.4%
Other HHS	163 (96)	168 (91)	187 (94)	+ 2.9%
NSF	602 (355)	670 (364)	794 (399)	+ 9.6%
Defense-Military	367 (216)	405 (220)	447 (225)	+ 2.2%
Energy	292 (172)	321 (175)	364 (183)	+ 4.7%
Agriculture	206 (121)	222 (121)	236 (119)	- 1.8%
NASA	144 (85)	163 (89)	174 (88)	- 1.3%
AID	67 (40)	53 (29)	58 (29)	+ 2.1%
Education	48 (28)	49 (27)	55 (28)	+ 4.4%
EPA	50 (29)	53 (29)	53 (26)	- 7.5%
Interior	40 (24)	45 (25)	49 (25)	+ 0.3%
Commerce	29 (17)	37 (20)	37 (19)	- 7.0%
Transportation	20 (12)	20 (11)	21 (10)	- 4.5%
ISTC	-- --	18 (10)	13 (7)	-33.6%
Automotive Basic Research	--	--	7 (4)	--
Other	40 (24)	41 (22)	44 (22)	- 0.3%
Total				
Current Dollars	\$3,839	\$4,194	\$4,596	
Constant FY 1972 Dollars	(2,265)	(2,281)	(2,312)	+ 1.3%

Source: "OMB Data for Special Analysis K." Conversion to constant FY 1972 dollars by authors based on OMB deflators.

¹Constant FY 1972 dollars are shown in parentheses.

The Administration has expressed the hope that the real increases in basic research and support of R&D at colleges and universities will help ameliorate some of the problems currently facing academic science, including the growing obsolescence of equipment and the lack of opportunities for young investigators.

Agency R&D Totals

The composition by agency of the OMB totals for conduct of R&D and R&D facilities is shown in Table 7. Some agencies with R&D-related activities are excluded from the totals, including the congressional Office of Technology Assessment (\$14.2 million) and the White House Office of Science and Technology Policy (\$2.9 million). Also excluded are "off-budget" agencies such as the U.S. Postal Service, which is planning to conduct about \$27.3 million of R&D in FY 1981. Table 7 does not include any of the funds to be expended through the proposed Energy Security Corporation intended to stimulate production of alternative fuels, a portion of which may go to support R&D activities. Also not included are \$50 million in coal R&D for FY 1980 and a like amount for FY 1981 to be funded in connection with the windfall profits tax. Two other kinds of R&D support are also excluded from the table: tax savings to industry through special tax code provisions for R&D (estimated at \$1.97 billion in 1981), and allowances for "Independent R&D" under some procurement and R&D contracts to private industry, particularly from the Department of Defense.

Table 7. Research and Development in the FY 1981 Budget by Agency
in Current Dollars (Budget Authority in millions)

	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget	% Change FY 1980 to 1981
Total Conduct of R&D	\$28,936	\$31,818	\$36,298	+ 14.1%
Total R&D Facilities	1,515	1,699	2,012	+ 18.4%
Total, R&D	\$30,451	\$33,517	\$38,310	+ 14.3%
Conduct of R&D				
Defense--Military	\$12,660	\$13,835	\$16,799	+ 21.4%
NASA	4,411	5,114	5,617	+ 9.8%
Energy	4,556	4,860	5,093	+ 4.8%
HHS	3,475	3,761	3,982	+ 5.9%
(NIH)	(2,957)	(3,191)	(3,355)	(+ 5.2%)
NSF	808	897	1,056	+ 17.7%
Agriculture	663	718	766	+ 6.7%
EPA	383	412	446	+ 8.3%
Interior	408	407	416	+ 2.2%
Labor	134	273	385	+ 41.0%
Commerce	331	367	418	+ 14.0%
Transportation	337	345	380	+ 9.9%
Nuclear Regulatory Commission	157	204	228	+ 11.9%
Education	152	146	163	+ 12.2%
Veterans Administration	123	126	135	+ 6.6%
AID	107	59	70	+ 20.0%
ISTC	--	60	55	- 7.8%
HUD	56	48	52	+ 8.3%
Smithsonian	37	39	45	+ 13.5%
Justice	42	43	42	- 3.5%
TVA	15	23	34	+ 45.9%
Corps of Engineers	26	30	32	+ 8.8%
FEMA	13	11	23	+114.8%
Automotive Basic Research	--	--	20	--
Treasury	13	12	12	- 2.4%
Personnel Management	6	7	8	+ 23.5%
Library of Congress	6	5	5	- 1.9%

(continued on next page)

(Table 7 continued)

	FY 1979 Actual	FY 1980 Est.	FY 1981 Budget	% Change FY 1980 to 1981
Arms Control & Disarmament Agency	4	4	4	+ 5.4%
Consumer Product Safety Commission	4	4	4	- 2.8%
FCC	3	4	3	- 15.4%
State	2	2	2	--
Advisory Commission on Inter-governmental Relations	2	2	2	--
FTC	2	1	1	+ 7.7%
Total, Conduct of R&D	<u>\$28,936</u>	<u>\$31,818</u>	<u>\$36,298</u>	<u>+ 14.1%</u>
R&D Facilities				
Energy	\$ 886	\$1,032	\$1,257	+ 21.8%
Defense--Military	298	352	468	+ 32.9%
NASA	148	156	120	- 23.1%
HHS	55	31	55	+ 80.7%
(NIH)	(49)	(30)	(16)	(- 46.8%)
Agriculture	53	21	22	+ 4.8%
NSF	30	26	20	- 25.3%
Transportation	13	25	20	- 17.8%
Veterans Administration	--	10	18	+ 83.5%
TVA	24	37	15	- 58.8%
Interior	2	1	7	+458.3%
EPA	1	1	4	+192.9%
Consumer Product Safety Commission	3	3	3	--
Commerce	1	3	2	- 44.1%
Smithsonian	1	1	1	+ 71.4%
Total, R&D Facilities	<u>\$1,515</u>	<u>\$1,699</u>	<u>\$2,012</u>	<u>+ 18.4%</u>
Total, R&D	<u>\$30,451</u>	<u>\$33,517</u>	<u>\$38,310</u>	<u>+ 14.3%</u>

Source: "OMB Data for Special Analysis K."

Table 7 shows changes from FY 1980 to 1981 for R&D by agency in current dollars. In order to understand real trends in funding, it is necessary to take into account the effects of inflation, now assumed by the Administration to be running at 8-9%. Given that the economy has yet to make its long anticipated slowdown, however, both government and private economists are substantially more pessimistic about the inflation outlook now than they were even a few weeks ago, and this rate may well be higher.

Using the Administration's assumed inflation rate of 8-9%, the totals for both conduct of R&D and R&D facilities increase substantially in real terms. In conduct of R&D, the increase for DOD reflects the Administration's pledge to provide for real growth in defense in FY 1981. Among the major R&D agencies, NSF also receives a real increase, reflecting the President's long standing commitment to basic research funding. The very substantial Department of Labor increase represents social science R&D associated with the Administration's welfare reform proposals, scheduled to go into effect in 1982. Among the major agencies, the Department of the Interior suffers the most substantial real decrease in R&D funds, with a proposed increase in current dollars of only 2.2% over the FY 1980 budget. Large real increases are proposed for some of the agencies with smaller R&D budgets, including the Federal Emergency Management Agency (FEMA) and the Tennessee Valley Authority (TVA).

On the whole, given the overall budget climate, it would appear that R&D, including basic research, fares rather well in the Carter Administration's FY 1981 budget.

NATIONAL SCIENCE FOUNDATION FY 1981

*Association of American Universities
John C. Crowley*

Highlights

- . Total budget: \$1.148 million; \$154.15 million or 15.5% above the FY 1980 plan
- . Basic research: +16.9% to \$951.5 million; 13.9% increase in individual research project grants; sufficient to provide a 3 to 4% margin of real growth
- . Emphasis on physical sciences and engineering; particularly in experimental computer science, mathematics, chemistry, microstructures, neurosciences, ecosystems and environmental research
- . Applied research: +25.4% to \$93.4 million
- . New \$14.25 million, 1-to-1 matching, program to begin rehabilitation of university research laboratories
- . Continued decline in support for major equipment such as accelerators, telescopes, ships and aircraft - \$13.6 million, down from \$22.8 million in FY 1979
- . Expansion of support for research equipment and instrumentation - \$95.3 million, up from \$78.3 million in FY 1979
- . \$3 million for operating of 14 regional instrumentation centers; no new starts; intensive evaluation of the program
- . \$20 million (+183.7%) for industry/university cooperative research
- . \$18.2 million (+146.9%) for small business innovation (+\$10 million) and industrial technology (+\$2.6 million) to establish at least one university/ industry cooperative research center in "generic science".
- . \$10 million to start 10-year ocean margin drilling program to be jointly funded by industry
- . \$85.7 million (+9.6%) for science education
- . Further adjustment to \$4800 in stipends for graduate fellows and to \$4500 for graduate trainees; no increase in new starts; cost of education allowances remain fixed at \$3400

Background

The National Science Foundation continues to lead the Administration's effort to provide stable, broad support for basic research. Using a 9% GNP deflator the Administration proposed a government-wide increase in basic research of 12%, sufficient to provide about 3% real growth. Total government obligations for basic research are estimated to increase 12%. The proposed 17% increase for NSF basic research program compares favorably with comparable increases in other agencies: DOE 13%, USDA 12%, DOD 20-25%. Administration estimates for the period 1978-81 project 40%, 9% real growth, increase in support for federally funded basic research.

As shown in the following table, federal support of basic research in certain fields declined during the period 1967-80. In response, the 1981 budget will pay particular attention to improving support for the physical sciences and mathematics.

FEDERAL SUPPORT OF BASIC RESEARCH IN
CONSTANT (1972) DOLLARS BY MAJOR FIELDS
(OBLIGATIONS IN THOUSANDS OF DOLLARS)

<u>Fields of Science</u>	<u>1967</u>	<u>1980</u>	<u>Real Growth 1967-80</u>
Total.....	2,324,744	2,520,892	+ 8.4
Life Sciences.....	889,031	1,057,802	+19.0
Psychology.....	66,518	52,360	-21.3
Physical Sciences.....	750,369	649,182	-13.5
Environmental Sciences.....	263,424	352,134	+33.7
Mathematics.....	80,859	67,376	-16.7
Engineering.....	192,608	234,943	+22.0
Social Sciences.....	69,145	73,690	+ 6.5
Other.....	12,739	33,405	+162.2

Note: The GNP implicit price deflator was used for 1967 and an estimate of 9 percent (by OMB) used for 1980.

Source: National Science Foundation

The 1981 NSF budget provides for major increases in the programs of the three major basic research directorates: Mathematical and Physical Sciences - +16.7%; Astronomical, Atmospheric, Earth and Ocean Sciences - +10.8%; Engineering and Applied Science - +22.5% and Biological, Behavioral and Social Sciences - +9.3%. The five programs of the Mathematical and Physical Sciences directorate are budgeted to increase from between 14.7% and 28.1%. Three of the four basic engineering sciences programs will increase between 14% and 28% and the Atmospheric, Earth and Ocean Sciences programs will increase between 10 and 14%. Of the Biological, Behavioral and Social Sciences programs, only physiology, cellular and molecular biology will increase more than 10% (11.3%); other programs are held at or below the projected 9% inflation factor.

Mathematical and Physical Sciences

The \$37.8 million increase to \$264.2 million will provide for increased support in mathematics, physics, chemistry and materials research. Total project support is estimated at \$174.7 million. The 16.7% increase is an attempt to provide "significant real growth" in these disciplines. It reflects an evaluation that "overall federal support for research in the MPS disciplines has eroded to the point where adequate funding is no longer available to provide the most highly qualified investigators with the resources required to carry out their research in an optimum manner."

The National Science Foundation has a heavy, sometimes unique, responsibility for funding these disciplines. The NSF accounts for 90 - 95% of all federal support for core mathematics, 50 - 80% of support for basic research in computer science, from 25 - 95% of the support for the various subdisciplines of physics, from 45 - 50% of academic basic research in chemistry and 55% of all federal support for basic materials research in universities.

The budget stresses "augmented research project support for all disciplines including provision of modern research instrumentation." NSF seeks to provide "real growth in average award size in order to provide more adequate support, including that to young investigators, for graduate students, post-doctoral fellows, equipment, and materials and supplies." In addition, the budget meets "essential requirements" of national user facilities, which represent an effective, and often the only, mode for carrying out certain types of research."

Special emphasis is given to improved academic research in experimental computer science. Support for instrumentation and equipment for research projects, special equipment programs, university laboratories and major user facilities also is increased by \$5.5 million to \$42.4 million.

Astronomical, Atmospheric, Earth and Ocean Sciences

The construction of the Very Large Array (VLA) for radio astronomy has been completed and a \$1.8 million increase has been provided for the first year of full operations. In addition, a new 25 meter diameter millimeter wave telescope will enter the detail design phase; construction is scheduled for FY 82-84 at an added cost of \$27 million. Increases in atmospheric sciences include \$4.3 million for expanded project support; an increase of \$3.3 million, for the National Center for Atmospheric Research and an increase of \$300,000 for the National Scientific Balloon facility. Project support for the Earth and Ocean Sciences will be increased. Support for instrumentation and equipment (\$26.7 million) will include \$6.6 million for major equipment, including one new research ship, and \$20.1 million for equipment for research projects and national centers.

U.S. Antarctic Program

Over one half of the FY 1981 increase of \$7.6 million will be absorbed by inflation. Forty percent of the operation support increase will be used to repair and maintain aircraft.

Ocean Drilling Programs

Ten million dollars will be matched by the petroleum industry to develop the ocean margin drilling project to a decision point on a ten-year effort.

Biological, Behavioral and Social Sciences

About 50% of the \$15.5 million increase will go to physiology, cellular and molecular biology. The \$7.6 million increase in those programs will support studies of cell-cell interactions, the procurement of instrumentation and development of new instrumentation; studies of membrane structure and research on macromolecules. Across BBSS programs, \$16.1 million will be allocated to research instrumentation as part of research grants and to foster sharing of equipment.

Engineering and Applied Sciences

On July 1, 1979 NSF again reorganized its applied research arm. Engineering activities were combined with programs of the former Applied Science and Research Applications (ASRA) directorate. (ASRA was the successor of the controversial RANN program). Engineering and ASRA programs were combined to consolidate and strengthen engineering activities, enhance applied and problem-focused research and give attention to the key role of engineering in the transfer of science into technology. In FY 1981 about \$15 million of the proposed \$25 million increase for the eight EAS programs will be targeted on Small Business Innovation and Industrial Technology and on a "sharply focused effort in microstructures and computer engineering research." The \$10.8 million increase for Small Business and Industrial Technology is to carry out the President's industrial innovation program announced last October 31.

Scientific, Technological and International Affairs

International cooperative science activities account for almost half of the STIA effort. The 1981 budget provides for the continuation of three initiatives begun in FY 1980: (1) increased U.S. scientific interaction with western Europe, (2) increased scientific exchange with China and (3) provision for scientific cooperation with developing countries. Perhaps significant is the decision to exclude the \$3.2 million for US/USSR cooperative research. This program is displayed separately in the budget without change from 1980.

Cross-Directorate Program

This year the NSF budget includes a new category of Cross Directorate Programs. Grouped into this budget activity are a number of programs not related to any one field of science but which cut across several fields. Of particular interest is the \$13 million increase proposed for industry/university cooperative research, an increase which like the small business initiative, also is related to the President's industrial innovation program.

Of particular significance to research universities is a new \$14.3 million matching program of university research facilities improvement. Budgeted to a somewhat reduced and stabilized commitment to US/USSR cooperative research is a \$2 million, doubled, commitment to US/China cooperation in basic sciences.

The recently created Regional Instrumentation Facilities program, an attempt to "offer an economical solution to the desire to make costly instrumentation widely available to qualified scientists," now operates 14 regional laboratories. During FY 1981 no additional facilities will be established and existing programs will be subject to "an intensive evaluation process." The FY 1981 budget is \$1.8 million below the FY 1981 plan. It will permit operational support and equipment necessary to maintain regional facilities at state-of-the-art.

In January, 1978, in response to Congressional direction to broaden the geographic distribution of NSF research funds and on the recommendation of an NSF Task Force, NSF established an experimental program to stimulate competitive research. The program was designed to stimulate research competitiveness, within the peer review system, in states which historically had been relatively non-competitive for NSF basic research awards. During FY 1979 planning awards were made to ad hoc committees in seven states: Arkansas, Maine, Montana, North Dakota, South Carolina, South Dakota and West Virginia. State plans developed with these awards now will compete for implementation awards averaging \$700,000 per year for up to five years. In FY 1981 planning awards also will be made to Vermont, Idaho and Mississippi and second year support will be provided for some of the original group. Second year awards for the rest of the original seven states will be made in FY 1982.

Science Education

Increases in science education programs include \$425,000 to increase graduate fellowship and traineeship stipend support. Other increases include Student-Oriented Programs (\$820,000), Information Dissemination in Science Education (\$404,000), Research in Science Education (\$523,000).

Particularly significant is a \$2 million increase in the Development in Science Education Program. This continues an effort to create new opportunities for early adolescence, career access for minorities and women, informal out-of-classroom materials and to improve the quality of science teaching in higher education. Among programs reduced are the Student Originated Studies Program which has been combined with the Undergraduate Research Participation Program. Cuts of \$448,000 in the Comprehensive Assistance to Undergraduate Science Education (CAUSE) Program and \$286,000 in Instructional Scientific Equipment Program are proposed. Increases in other programs are proposed to offset these reductions.

Part of the \$3.6 million for scientific personnel improvement will be used to increase fellowship and traineeship stipends which "remain below the poverty level for a single person." An increase of \$1.3 million is provided for the minorities, women and physically handicapped program to create minority student apprenticeships at the senior high school level and for opportunities for women in science. The science faculty programs is increased \$1 million to upgrade faculty in two-year and four-year colleges and undergraduate divisions of universities. Increases proposed for science education, development and research reflect expanded efforts to develop educational instructional materials for early adolescence, improve formal and informal systems of science education and generate new knowledge for improvements in science education. Almost all of the \$1.1 million increase for the Science and Society Program will be used for the public understanding of science program. Augmented support will be provided for science museums and for projects designed to reach youth, minorities, amateur scientists and other groups now outside the normal flow of scientific and technical information.

Special Foreign Currency

Some U.S. owned foreign currencies in Egypt, India and Pakistan are designated by the Department of Treasury as "excess to the requirements of U.S. government." With these funds NSF supports scientific activities designed to enhance participation by U.S. scientists and institutions in international science projects and to translate scientific and technical literature. No increase is proposed for FY 1981.

BUDGET SUMMARY OF OBLIGATIONS BY ACTIVITY AND SUBACTIVITY SHOWING DOLLAR AND PERCENTAGE CHANGES, FY 1981/FY 1980

(Millions of Dollars)

Activity & Summary	FY 1979	FY 1980 Current Plan	FY 1981 Budget Request	Difference	
				FY 81/FY 80 Amt.	Pct.
RESEARCH & RELATED ACTIVITIES APPROPRIATION					
Mathematical and Physical Sciences					
Mathematical Sciences.....	22.8	24.9	29.3	4.4	17.7
Computer Research.....	16.8	18.2	23.3	5.1	28.1
Physics.....	61.7	63.4	73.5	10.1	16.0
Chemistry.....	45.2	51.4	59.5	8.1	15.7
Materials Research.....	62.4	68.5	78.6	10.1	14.7
Subtotal, MPS.....	208.9	226.4	264.2	37.8	16.7
Astronomical, Atmospheric, Earth and Ocean Sciences					
Astronomical Sciences.....	59.2	57.0	60.2	3.2	5.7
Atmospheric Sciences.....	59.1	63.2	71.1	7.9	12.6
Earth Sciences.....	24.9	25.3	27.9	2.6	10.4
Ocean Sciences.....	62.4	66.6	76.0	9.4	14.1
Arctic Research.....	6.0	5.8	6.1	.3	4.6
Subtotal, AAEO.....	211.6	217.9	241.3	23.4	10.8
U.S. Antarctic Program					
U.S. Antarctic Research Program.....	7.3	8.0	9.3	1.3	16.2
Operations Support.....	43.8	47.8	54.1	6.3	13.1
Subtotal, USAP.....	51.1	55.8	63.4	7.6	13.5

BUDGET SUMMARY OF OBLIGATIONS BY ACTIVITY AND
SUBACTIVITY SHOWING DOLLAR AND PERCENTAGE CHANGES,
FY 1981/FY 1980—Continued

(Millions of Dollars)

Activity & Summary	FY 1979	FY 1980 Current Plan	FY 1981 Budget Request	Difference FY 81/FY 80 Amt.	¹ Pct.
Cross-Directorate Programs					
Industry/University Cooperative Research..	5.4	7.0	20.0	13.0	183.7
Special Facilities & Instrumentation:					
Univ. Research Facilities Improvement...	—0—	—0—	14.3	14.3	—0—
2-Yr./4-Yr. College Instrumentation.....	.6	3.3	3.0	-.3	-9.1
Regional Instrumentation Facilities.....	5.0	4.8	3.0	-1.8	-37.5
Subtotal, Spec. Facilities & Instrmntn..	5.6	8.1	20.3	12.2	150.0
Cross-Directorate Int'l. Programs:					
US/USSR Cooperative Research Program....	3.4	3.2	3.2	—0—	—0—
US/China Cooperation in Basic Sciences..	—0—	1.0	2.0	1.0	100.0
Subtotal, Cross-Directorate Int'l. Prgms.	3.4	4.2	5.2	1.0	23.8
Other Programs:					
Research Initiation in Minority Instns..	.4	1.0	1.0	—0—	—0—
Experimental Program to Stimulate					
Competitive Research.....	.9	3.9	2.7	-1.2	29.9
Post-Doctoral Fellowships.....	(² 1.8)	(.9)	(.9)	.9	2.0
Decision and Management Sciences.....	—0—	—0—	1.0	1.0	—0—
Waterman Award.....	.1	.1	.1	—0—	—0—
NSF Planning and Evaluation.....	1.0	1.2	.8	-.4	-36.2
Subtotal, Other Programs.....	2.4	6.2	6.5	.3	5.3
Subtotal, Cross-Directorate Programs....	16.8	25.5	52.0	26.5	103.5
Program Development & Management.....	54.7	60.6	60.8	.2	.4
Subtotal, Research & Related Activities..	842.9	910.1	1,056.8	146.7	16.1
Science Education Activities Appropriation					
Scientific Personnel Improvement.....	33.1	31.6	35.2	3.6	11.4
Science Education Resources Improvement...	28.6	24.0	24.2	.2	.8
Science Education Development & Research..	12.0	14.9	17.5	2.6	17.1
Science and Society.....	6.3	7.7	8.8	1.1	15.0
Subtotal, Science Education Activities..	80.0	78.2	85.7	7.5	9.6
Subtotal, Dollar Activities.....	922.9	988.3	1,142.5	154.2	15.6
Special Foreign Currency Appropriation.....	4.0	5.5	5.5	—0—	—0—
Total, NSF.....	926.9	993.8	1,148.0	154.2	15.5

¹ Percentages based on unrounded tabular amounts.

² Post-Doctoral Fellowships included in Science Education Activities prior to FY 1981.

BUDGET SUMMARY OF OBLIGATIONS BY ACTIVITY AND
SUBACTIVITY SHOWING DOLLAR AND PERCENTAGE CHANGES,
FY 1981/FY 1980—Continued
(Millions of Dollars)

Activity & Summary	FY 1979	FY 1980 Current Plan	FY 1981 Budget Request	Difference FY 81/FY 80	
				Amt.	Pct.
RESEARCH & RELATED ACTIVITIES APPROPRIATION					
Ocean Drilling Program					
Ocean Sediment Coring Program.....	10.6	15.9	17.3	1.4	9.0
Ocean Margin Drilling Program.....	1.0	3.6	10.0	6.4	177.8
Subtotal, ODP.....	11.6	19.5	27.3	7.8	40.2
Biological, Behavioral, and Social Sciences					
Physiology, Cellular & Molecular Biology.	62.3	67.2	74.8	7.6	11.3
Behavioral & Neural Sciences.....	33.1	35.4	38.7	3.3	9.2
Social & Economic Sciences.....	25.4	26.2	27.8	1.6	6.1
Environmental Biology	33.9	37.7	40.7	3.0	8.1
Subtotal, BBS.....	154.7	166.5	182.0	15.5	9.3
Engineering and Applied Science					
Engineering:					
Electrical, Computer & Systems Engrng....	17.0	17.6	22.5	4.9	27.8
Chemical and Process Engineering.....	13.0	13.9	16.7	2.8	20.0
Civil & Environmental Engineering.....	8.2	9.3	10.1	.8	8.9
Mechanical Sciences & Engineering.....	10.7	11.7	13.3	1.6	14.2
Subtotal, Engineering	48.9	52.5	62.6	10.1	19.3
Applied Sciences:					
Applied Research.....	17.6	17.6	18.7	1.1	6.1
Problem-Focused Research.....	32.6	28.9	30.5	1.6	5.6
Intergovernmental Science.....	5.1	5.5	7.0	1.5	27.3
Small Business Innovation and Industrial Technology.....	5.7	7.3	18.2	10.9	146.9
Subtotal, Applied Science.....	61.0	59.3	74.4	15.1	25.3
Subtotal, EAS.....	109.9	111.8	137.0	25.2	22.5
Scientific, Technological & Int'l. Affairs					
Int'l. Cooperative Science Activities....	10.6	12.0	12.9	.9	7.4
Policy Research & Analysis.....	5.5	5.7	6.6	.9	15.7
Science Resources Studies.....	3.1	3.2	3.4	.2	6.6
Information Science & Technology.....	4.4	5.2	5.9	.7	14.5
Subtotal, STIA.....	23.6	26.1	28.8	2.7	10.5

¹ Percentages based on unrounded tabular amounts.

² Post-Doctoral Fellowships included in Science Education Activities prior to FY 1981.

Research Facilities, Equipment and Instrumentation

Foundation support for research facilities and equipment increases from \$104.5 million to \$126.5 million (+21.1%). Of this, \$14.25 million will be used on a 1-to-1 matching basis to upgrade university research laboratories. Expanded support also will be provided for instrumentation and equipment programs in two-year and four-year institutions and to operate the 14 regional instrumentation facilities already established.

RESEARCH FACILITIES AND EQUIPMENT
Budget Authority/Obligations in Millions of Dollars

FISCAL YEAR AND ACTIVITY	Land, Buildings, and Fixed Equipment	Major Equipment	Other Equipment and Instru- mentation	Total
FY 1979				
Mathematical and Physical Sciences.....	—0—	\$11.2	\$28.0	\$39.2
Astronomical, Atmospheric, Earth and Ocean Sciences.....	4.9	10.9	16.2	32.0
U.S. Antarctic Program.....	2.5	—0—	5.7	8.2
Biological, Behavioral & Social Sciences..	—0—	—0—	17.1	17.1
Engineering and Applied Science.....	—0—	0.7	11.3	12.0
Total, FY 1979.....	7.4	22.8	78.3	108.5
FY 1980				
Mathematical and Physical Sciences.....	—0—	6.4	30.4	36.8
Astronomical, Atmospheric, Earth and Ocean Sciences.....	1.7	7.1	17.5	26.3
U.S. Antarctic Program.....	2.6	1.0	5.0	8.6
Biological, Behavioral & Social Sciences..	—0—	—0—	14.6	14.6
Engineering and Applied Science.....	—0—	0.5	12.0	12.5
Cross-Directorate Programs.....	—0—	—0—	5.7	5.7
Total, FY 1980.....	4.3	15.0	85.2	104.5
FY 1981				
Mathematical and Physical Sciences.....	—0—	6.5	35.9	42.4
Astronomical, Atmospheric, Earth and Ocean Sciences.....	0.1	4.8	21.8	26.7
U.S. Antarctic Program.....	3.2	1.6	4.5	9.3
Ocean Drilling Program.....	—0—	—0—	1.0	1.0
Biological, Behavioral & Social Sciences..	—0—	—0—	16.1	16.1
Engineering and Applied Science.....	—0—	0.7	13.1	13.8
Cross-Directorate Programs.....	14.3	—0—	2.9	17.2
Total, FY 1981.....	17.6	13.6	95.3	126.5
Difference—FY 1981/FY 1980.....	13.3	-1.4	10.1	22.0

CHEMISTRY IN THE FY 1981 BUDGET

*American Chemical Society
Nhung McLeod*

Overview

Chemistry is ubiquitous in the Federal R&D budget. In addition to the National Science Foundation which funds basic research in chemistry, many mission agencies such as the Department of Energy, the Department of Defense, the Environmental Protection Agency, and the National Institutes of Health support chemistry. However, some of the work supported by the mission agencies involve just the application of known chemistry principles or techniques during the course of research on other subject matters. Therefore, it is important to distinguish between basic research in chemistry, and the incidental chemistry work done by mission agencies. The total for programs involving chemistry shown in the tables for each agency is more indicative of the number of chemists supported by the agency than of the amount of basic research in chemistry.

The National Science Foundation is the prime source of support for basic research in chemistry performed at colleges and universities. Its requested budget for FY 1981 would provide for fairly even increases ranging from 15% to 17% across all NSF chemistry programs. Basic research in chemistry is also funded at a substantial level by the Department of Energy, where the request for Chemical Sciences is up 14.9%. The Department of Defense, which is the other major source of funding for basic research in chemistry, is requesting an increase of 18.2% for this purpose across the three services.

In conclusion, a look at the three federal agencies (NSF, DOE, DOD) that have a policy of supporting basic research in chemistry, as evidenced by their budget format, gives a favorable picture for basic research in chemistry in FY 1981. However, the picture is neither as favorable or as clear for three other agencies (USDA, NIH, EPA) that support chemistry as an incidental aspect of their major mission. It appears unlikely that funding for chemistry in FY 1981 will increase much at all in those agencies.

As the budgets of the individual agencies presented here are examined, it is important to keep in mind that the funds identified for chemical research are just estimates. They cannot be taken as absolute values, but only as indicators that are helpful for assessing funding trends.

National Science Foundation

- All chemistry disciplines funded by the Chemistry Division are slated for increases between 15% and 17%.
- The overall increase for programs funded under the Division of Chemical and Process Engineering is 20%. (The unusually high 30.4% increase under Engineering Energetics is for the upgrading of facilities in plasma chemistry and arc technology).
- The overall increase for all NSF programs which fund research in chemistry and chemical engineering is 16.1%.

Since the Chemistry Division is at the center of NSF support for basic research in chemistry, its programs will be examined in greater detail. A major policy decision has been made to use \$7 million of the \$8.1 million increase allocated for the Division to raise the average award size from \$57,127 to \$66,111. This will be accomplished partly by keeping the number of awards at the same level as in FY 1980 (900 awards). In FY 1981, the Chemistry Division will also initiate 40 new projects with a view toward helping young investigators. An equal number of projects will be terminated to allow for this redirection.

Table 1. NATIONAL SCIENCE FOUNDATION
(\$ thousand)

<u>PROGRAMS FUNDED BY</u> <u>CHEMISTRY DIVISION</u>	<u>Actual</u> <u>FY 1979</u>	<u>Current</u> <u>Plan</u> <u>FY 1980</u>	<u>Request</u> <u>FY 1981</u>	<u>% Change</u> <u>FY 80/81</u>
Structural & Thermodynamics	9,439	10,658	12,370	16.1
Quantum Chemistry	7,398	8,318	9,587	15.3
Chemical Dynamics	8,470	9,929	11,501	15.8
Chemical Analysis	5,140	5,783	6,653	15.0
Synthetic Inorganic & Organometallic	5,158	5,808	6,682	15.1
Synthetic Organic & Natural Products	5,559	6,158	7,137	15.9
Chemical Instrumentation	4,067	4,760	5,570	17.0
Subtotal, Chemistry Division	45,231	51,414	59,500	15.7
<u>PROGRAMS FUNDED BY CHEMICAL &</u> <u>PROCESS ENGINEERING DIVISION</u>				
Kinetics, Catalysis, & Reaction Engineering	1,835	2,520	2,960	17.5
Chemical & Biochemical Systems	2,330	2,400	2,750	14.6
Engineering Energetics	2,785	2,500	3,260	30.4
Thermodynamics & Mass Transfer	3,587	3,680	4,440	20.7
Particulate & Multiphase Processes	2,438	2,780	3,240	16.6
Subtotal, Engineering Division	12,975	13,880	16,650	20.0
<u>OTHER PROGRAMS INVOLVING CHEMISTRY</u>				
Materials Research:				
Solid State Chemistry	4,343	4,680	5,550	18.6
Polymers	3,836	4,140	4,900	18.4
Atmospheric Chemistry	3,082	3,700	4,800	29.7
Geochemistry	10,428	6,138	6,700	9.2
Marine Chemistry	3,507	3,850	4,350	13.0
Biochemistry	8,673	9,100	10,000	9.0
TOTAL PROGRAMS INVOLVING CHEMISTRY	92,075	96,902	112,450	16.1

The thrust to provide instrumentation (nuclear magnetic resonance, mass spectroscopy with multiple source capabilities, high-speed mini-computers, and lasers) for chemistry departments will continue in FY 1981, with an increase of \$724,000 to a total of \$3.946 million. An increase of \$86,000 is planned for National Resources for Computation in Chemistry, bringing the total for this program to \$814,000.

The Chemistry Division programs will continue their emphasis on submicron science, with an increase of \$500,000 bringing total funding to \$2.8 million. The other recurring emphasis is on the application of laser to chemical research, such as spectroscopic methods for structural analysis of reaction intermediates, light scattering for probing molecules in solution, characterization and time-resolved studies of transient species present on transition metal catalysts, studies of state-to-state chemistry, and sub-micron analytical methodology.

A remarkable aspect of the research plans highlighted in the budget request for NSF is that the projects are often tied to a current national problem, as evidenced by the research on catalysis and energy conversion, synthetic organic chemistry based on

renewable natural resources, heavy metal removal from environmental samples, and synthetic inorganic chemistry related to materials development. As expected, this orientation towards national problems is even more marked in the programs administered by the Chemical and Process Engineering Division than in the Chemistry Division.

A total picture of chemical research funding at NSF cannot be presented without mentioning the expansion of the agency-wide Industry-University Cooperative Research program, from \$10.6 million to \$30 million in FY 1981. In FY 1979, the second year of operation of the program, 4 of the 57 awards made were in chemistry. The FY 1981 expansion will undoubtedly provide additional funding for chemical research.

Department of Energy

The bulk of DOE chemical research is funded by the Chemical Sciences appropriation within Basic Energy Sciences. Last year, DOE proposed a large increase of 26.4% in the appropriations for Chemical Sciences, and Congress reduced it to 18.6%. The Department is requesting a smaller increase this year (\$74.4 million in total appropriations which consist of operating expenses, capital equipment, and construction; or \$63.3 million in operating expenses). In fact, the same percentage increase in operating expenses is requested for FY 1981 (14.9%) as was granted by Congress for FY 1980 (14.8%).

Table 2. DEPARTMENT OF ENERGY
(\$ thousand)

	FY 1980 Estimate	FY 1981 Request	% change FY 80/81
<u>Energy Supply R&D</u>			
<u>Solar: Biomass</u>			
Conversion Technology	24,500	11,500	-53.1
Research & Exploratory Development	8,300	14,400	+73.5
<u>Photovoltaics Advanced R&D</u>			
Materials/Cells R&D	29,000	30,000	+ 3.4
High-risk R&D	13,000	15,000	+15.4
<u>Geothermal</u>			
Geochemical Engineering & Materials	3,600	5,005	+39.0
<u>Storage</u>			
Electrochemical Systems	2,600	3,600	+38.5
Supporting Research	3,000	3,600	+20.0
Electrolytic Technology	1,500	1,400	- 6.7
Chemical/H Storage	4,400	2,600	-40.9
<u>Environment</u>			
Physical & Technological Studies	31,205	33,615	+ 7.7
<u>Basic Research</u>			
Materials Chemistry	10,890	12,650	+16.2
Chemical Sciences	55,100	63,300	+14.9
Geosciences	8,000	11,600	+45.0
University Institutional Agreements	2,300	7,700	+234.8
University/Laboratory Cooperative Program	2,800	3,800	+35.7
<u>FOSSIL ENERGY R&D</u>			
<u>Coal</u>			
Preparation & Analysis	12,650	11,000	-13.0
University Research	5,000	5,000	- 0 -
TOTAL, PROGRAMS INVOLVING CHEMISTRY	217,845	235,770	+ 8.2

Table 3. DEPARTMENT OF ENERGY
Chemical Sciences
(\$ thousand)

	FY 1980 Estimate	FY 1981 Request	% change FY 80/81
<u>Fundamental Interactions</u>			
Solar-Related Photochemistry	6,200	7,700	+24.2
Combustion Research	4,500	6,900	+53.3
Fossil-Related Research	2,000	2,200	+10.0
Fusion-Related Research (atomic physics)	2,000	2,200	+10.0
Non-Solar Photochemistry, Radiation Chemistry, Chemical Physics	1,400	1,400	- 0 -
Long-Term Energy Research	16,330	17,230	+ 5.5
	32,505	37,630	+15.8
<u>Process and Techniques</u>			
Chemical Energy	11,410	12,780	+12.0
Separations Research	5,935	6,730	+13.4
Analysis	4,115	4,480	+ 8.9
Chemical Engineering	1,135	1,680	+48.0
	22,595	25,670	+13.6
TOTAL, CHEMICAL SCIENCES - OPERATING EXPENSES	55,100	63,300	+14.9
CAPITAL EQUIPMENT	3,700	4,740	+28.0
CONSTRUCTION	6,300	6,500	+ 3.2

In FY 1981, the distribution of the \$63.3 million in operating expenses for Chemical Sciences is expected to be: 68% to DOE laboratories, 29% to universities, and 3% to other laboratories, including industrial facilities.

Two categories of research are funded under Chemical Sciences: Fundamental Interactions which is akin to long-term basic research, and Processes and Techniques which is more technology-oriented.

Fundamental Interactions will provide funding for joint research with Japan on photoconversion and photosynthesis, first year operation of the Combustion Research facility at Sandia Laboratories - Livermore, and work on the National Synchrotron Light Source. Research will be conducted on the effects of catalysts on light-induced chemical changes, and the mechanisms of soot formation in diesel fuel burning.

Processes and Techniques will fund research on basic organic chemistry and trace analysis related to coal gasification and liquefaction, isotope chemistry and separation of components of spent nuclear fuel, turbulence flow in fluid dynamics, conversion of carbon monoxide and hydrogen to bulk chemicals and synthetic fuels, and new thermodynamic cycles for obtaining hydrogen fuel from water.

Under the Chemical Sciences appropriation, \$ 6.3 million is requested for completion of the Chemical and Materials Sciences Laboratory at Lawrence Berkeley Laboratories, which will have capabilities for atomic resolution microscopy and photoelectron spectroscopy.

Two programs outside of Chemical Sciences deserve mentioning:

- The budget request for coal preparation and analysis is down from FY 1980. However, \$7 million is expected to be derived from the windfall profits tax for this important program, which includes both physical and chemical cleaning of coal. At present, there are no commercial chemical coal cleaning techniques. Research on chemical desulfurization will be conducted in both in-house and contractor laboratories.
- A new initiative is proposed for filling the gap between the discipline-oriented research supported by the Basic Energy Sciences program, and the engineering and demonstration work supported by the technology development programs. The proposed university institutional agreements (\$3 million) would support interdisciplinary teams focused on goal-oriented basic research in areas critical to technology development. DOE will release a broad competitive solicitation, and awards will be made on a highly selective basis. This new type of institutional agreement differs from the ten existing agreements which were made for very flexible purposes, ranging from research to education and information dissemination.

Department of Defense

Along with NSF and DOE, the Department of Defense is a major supporter of basic research in chemistry. Under the so-called "6.1 program" (which is the equivalent of basic research), DOD is planning to fund chemistry at \$47.5 million, an increase of 18.2% over FY 1980. An approximate 21% of the total "6.1 appropriations" (for all disciplines) will support research at universities.

Table 4. DEPARTMENT OF DEFENSE
6.1 Funding for Chemistry
(\$ million)

	FY 1980 Estimate	FY 1981 Request	% change FY 80/81
Army	15.6	18.8	+20.5
Navy	12.8	15.2	+18.7
Air Force	11.8	13.5	+14.4
TOTAL, 3 SERVICES	40.2	47.5	+18.2

The total in the above table does not include any funds that DARPA (Defense Advanced Research Projects Agency) will commit to chemical research, nor does it include funding for applied research in chemistry and chemical engineering research. It should be noted that the total DARPA request is down 6.6% in FY 1981, which implies a corresponding decrease in support of chemical research by DARPA.

Environmental Protection Agency

The work supported by EPA that is most akin to basic research in chemistry is the development of analytical methodologies. This activity constitutes a minor portion of the EPA programs involving chemistry and chemical engineering, and an even smaller portion of the overall research effort at the Agency, which is mostly on health effects.

Table 4 shows the EPA programs which, in whole or in part, consist of research on chemistry and chemical engineering. The first three programs (Characterization & Measurement Methods Development, Quality Assurance, Other Monitoring R&D) have a large analytical chemistry component, while the remaining programs are more engineering-oriented (in particular Control Technology). In FY 1981, the analytical chemistry programs show a modest increase ranging from 3.8% to 5.1%. The control technology programs are up by a strikingly large percentage (20.1%), particularly in the solid waste category (85.7%).

Table 5. ENVIRONMENTAL PROTECTION AGENCY
(\$ thousand)

	FY 1980 Estimate	FY 1981 Request	% change FY80/81
<u>Characterization & Measurement</u>			
<u>Methods Development</u>			
Air	7,871	8,044	+ 2.2
Water Quality	1,533	1,505	- 1.8
Toxic Substances	603	955	+58.4
	10,007	10,504	+ 5.0
<u>Quality Assurance</u>			
Air	4,460	4,655	+ 4.4
Water Quality	5,096	5,289	+ 3.8
Drinking Water	988	1,008	+ 2.0
Pesticides	548	565	+ 3.1
	11,092	11,517	+ 3.8
<u>Other Monitoring R&D</u>			
Air	5,085	5,171	+ 1.7
Water Quality	4,480	4,145	- 7.5
Energy	8,248	9,418	+14.2
	17,813	18,734	+ 5.2
<u>Control Technology</u>			
Air	4,067	4,099	+ 0.8
Water Quality	11,505	10,918	- 5.1
Solid Waste	14,243	26,446	+85.7
Toxic Substances	1,648	1,772	+ 7.5
Energy	31,239	37,512	+20.1
	62,702	80,747	+28.8
<u>Transport and Fate of Pollutants</u>			
Air	12,618	13,106	+ 3.9
Water Quality	1,409	1,267	-10.1
Toxic Substances	2,343	3,017	+28.8
	16,370	17,390	+ 6.2
<u>Other Research</u>			
Anticipatory Research	14,739	14,745	- 0 -
Toxic Substances - Technical Support	2,085	2,292	+ 9.9
	16,824	17,037	+ 1.3
<u>TOTAL, PROGRAMS INVOLVING CHEMISTRY</u>	134,808	155,929	+15.7

Under Characterization & Measurement Methods Development, work on inhalable and fine particulate matter will be emphasized, while the effort to identify recurring chemicals in industrial wastewaters that cannot be tentatively identified through matching of spectra in the computerized file will be reduced. Work will continue on the identification of toxic organic chemicals common to wastewaters of the 21 industrial categories identified in the NRDC consent decree. The effort to characterize toxic substances in sediments will be expanded, and similar work will be initiated for toxic substances in plants and marine animals. The research on identification of PCB's in oils will continue as well as the standardization of High Pressure Liquid Chromatography detector systems for individual toxic chemicals.

Funding for the agency-wide Quality Assurance program will be increased. The program will continue to validate methods, perform audits for particulate monitoring networks, develop automated lab testing system for drinking water, and maintain a repository of reference samples, including pesticide samples.

Under Other Monitoring R&D activities, EPA will report on the feasibility of using multi-spectral scanner data for mapping polluted air transport; evaluate ten methods for priority hazardous volatile organic chemicals; evaluate continuous monitoring systems for toxic metals, total phenols, oil, and total organic carbon; and develop reference methods for priority pollutants, toxic and hazardous substances, and chlorinated aromatics.

National Institutes of Health

The National Institutes of Health do not have a budget process for chemistry. The total of the funds supporting chemical research can only be computed retrospectively, by looking at the computer list of the grants awarded in a given year. However, it is fairly well accepted that year after year chemical research funding remains a constant proportion of the overall NIH budget. Therefore, the overall funding trend is a good indication of the trends for chemistry. In addition, it is known that for chemistry research (outside of biochemistry and the life sciences), the two major funding sources are the National Cancer Institute and the Institute of General Medical Sciences.

The FY 1981 overall budget for NIH, and the budgets of the two institutes mentioned indicate that chemistry funding is not likely to increase much at NIH. However, since there is a major emphasis at NCI on cancer cause and prevention (an increase of 8.3% as compared to last year's requested increase of 0.4%), and this is a major source of funding for chemical research, it is possible that chemistry funding may not be as low as indicated by the NCI budget.

Table 6. NATIONAL INSTITUTES OF HEALTH
(\$ thousand)

	FY 1980 Estimate	FY 1981 Request	% change FY 80/81
National Cancer Institute	1,000,802	1,007,800	+0.7
National Institute of General Medical Sciences	312,628	331,639	+6.1
.....			
TOTAL, NIH	3,442,641	3,581,547	+4.0

Department of Agriculture

The USDA in-house research unit, Agricultural Research, is the Department's major source of funds for chemical research, most of which is found under the appropriation for Processing, Storage and Distribution, Food Safety, and Consumer Services shown in table 7. The FY 1981 request for this appropriation is 0.5% below the previous year's level. This is a smaller decrease than the corresponding 8.9% decrease proposed last year but restored by Congress.

Table 7. DEPARTMENT OF AGRICULTURE
Agricultural Research (In-House)
(\$ thousand)

	FY 1980 Estimate	FY 1981 Request	% change FY 80/81
Processing, Storage & Distribution			
Efficiency Research	54,712	53,330	- 2.5
Research to Expand Agricultural Exports	2,588	2,601	+ 0.5
Research to Improve Human Health & Safety	18,531	19,488	+ 5.2
Research on Consumer Services	691	691	- 0 -
TOTAL, ABOVE PROGRAMS	76,522	76,110	- 0.5-
TOTAL, R&D AT USDA	743,000	786,000	+ 5.8

The budget for the programs listed in table 7 reflect the termination of wool and mohair research (\$1.2 million) and research on the development of industrial products based on cereals and oilseeds (\$1.5 million), and the reduction of research on industrial use of animal fats (\$258,000). These cuts are based on the ability of industry to assume the work. The increase in food safety research will fund the development of rapid detection and assessment techniques for toxic residue analysis.

Overall, the new emphasis in USDA research seems to be in areas which involve more biology and biochemistry than chemistry.

National Bureau of Standards

The National Bureau of Standards funds a relatively small amount of chemical research compared to other agencies. However, the Bureau performs more research than is indicated in its budget because of its work for other federal agencies on a reimbursement basis.

Most of the chemistry research is funded under the Measurement Research and Standards activity, while a small amount is funded under the "competence program". The latter was initiated in FY 1979 to counter the increasingly short-term focus in NBS research in the 1970's due to legislative requirements addressing specific national problems. In FY 1980, some of the projects funded under the competence program were in chemistry: laser chemistry, and soot formation processes. The competence program is slated for a significant increase of 47.9% in FY 1981, and some of this increase will most probably be for chemical research.

Three new projects involving chemistry will be funded under the Measurements Research and Standards activity. One is for research in time-resolved measurement of thermodynamic variables using a laser optical system. The second is for developing methods of quantitative compositional mapping (i.e. distribution of elements or molecules within a sample). The third proposal is for the study of two innovative metal processing technologies which have been identified by the 1979 NAS/NSF five-year outlook report as promising: rapid solidification processing, and high-speed casting using partially solidified alloys.

Table 8. NATIONAL BUREAU OF STANDARDS
Measurement Research and Standards
(\$ thousand)

	<u>FY 1980</u> <u>Estimate</u>	<u>FY 1981</u> <u>Request</u>	<u>% change</u> <u>FY 80/81</u>
<u>Physical and Chemical Measurements</u> <u>and Standards (M&S)</u>			
Fundamental Physical M&S	8,030	9,030	12.4
Analytical Chemical M&S	2,089	2,489	19.1
<u>Materials and Thermodynamics M&S</u>			
Materials Science	23,474	15,774	17.1
Thermodynamic and Molecular Science	3,921	4,321	10.2
<u>Competence Programs</u>	<u>4,176</u>	<u>6,176</u>	<u>47.9</u>
<u>TOTAL, PROGRAMS INVOLVING CHEMISTRY</u>	<u>31,690</u>	<u>37,790</u>	<u>19.2</u>

American Association of State Colleges and Universities

One Dupont Circle/Suite 700/Washington, D.C. 20036 (202) 293-7070

March 31, 1980

The Honorable Richard S. Schweiker
Subcommittee on Health & Scientific Research
4222 Dirksen
Washington, D. C. 20510

Dear Senator Schweiker:

As Vice President for Governmental Relations of the American Association of State Colleges and Universities (AASCU) I want to express our concerns with the FY 1981 NSF budget.

We were particularly distressed to hear NSF Director Richard Atkinson's remarks during the NSF authorization hearings of the Senate Health and Scientific Research subcommittee on March 25, 1980. His statement that "there will be heavy cuts in science education..." is bad news for AASCU. It is also bad news for the great majority of all public and private colleges (probably at least 2,300 in existence) which are primarily teaching rather than research institutions.

AASCU represents 338 state colleges and universities located throughout the U.S. with a combined enrollment of approximately two and one-half million students. The institutions award 45% of all BA degrees in the U.S. This includes the following institutions in the state of Pennsylvania: Bloomsburg State College, California State College, the Capitol Campus of Pennsylvania State University, Cheyney State College, Clarion State College, East Stroudsburg State College, Edinboro State College, Indiana University of Pennsylvania, Kutztown State College, Lincoln University, Lock Haven State College, Mansfield State College, Millersville State College, Shippensburg State College, Slippery Rock State College, University of Pittsburgh at Johnstown, and West Chester State College.

While many of our member institutions have developed outstanding graduate programs with opportunities for research, the highest priority of AASCU institutions is to provide quality undergraduate education. In our science programs, state colleges and universities regard the Science Education Directorate as a vital source of needed funds. These funds are used to provide high quality training in science, to improve undergraduate science and to revitalize curricula. They also reach most young people who may choose scientific careers. The importance of science education funds to undergraduate institutions was clearly and fully discussed by Dr. Thomas Wenzlau, Ohio Wesleyan University president, before your subcommittee and we fully endorse his testimony.

The potential cuts mentioned by Dr. Atkinson before your subcommittee on March 25, 1980 are distressing news to us, particularly in view of the fact

that research funds appear to be protected from any proposed decreases. We are not advocating a decline in the support for basic research for that would be unwise in terms of our national needs and interests. Nor is it a question of choosing between basic research or science education because in the long run, neither can proceed effective or efficiently without the other. This interdependence was recognized in 1950 when Congress charged NSF to "develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." As disturbing as Dr. Atkinson's statement is I am heartened by your assurance that the committee "has not sided with the administration on the cuts" yet and hope that you will continue to maintain this position.

The Health and Scientific Research subcommittee meets to consider the FY 1981 authorization for NSF at a troublesome time. Across the country colleges and universities have been forced to deal with the devastating impact of sustained high inflation, and for this reason we would welcome sound measures designed to deal with this problem. While we are prepared and willing to address the economic problems confronting this country, we urge the subcommittee to preserve those NSF programs that will advance U.S. science and technology in the decades ahead.

We thought it might be helpful for you to know a few of the ways in which science education funds have helped AASCU institutions in Pennsylvania in the past few years.

-An Undergraduate Research Participation Project grant to Slippery Rock State College permitted talented and promising students to participate in an economic analysis of the energy problem. The focus of this research was on the value of service pricing, fair rate of return regulation and route service certifications.

-The Minority Institutions Science Improvement program which assists predominantly minority institutions in developing and maintaining quality science education programs for their students supported projects at Cheney State College in mathematical science and at Lincoln University in natural and mathematical sciences.

-The Dissemination of Science Education Information program awarded a grant to Clarion State College. The grant supported conferences and workshops for school decision makers to familiarized them with a large variety of science instructional materials, practices and technologies available for JHS science curricula.

I wish to thank you for your past support of NSF and pledge our cooperation in addressing the difficulties that face us.

Sincerely yours,

John P. Mallan
Vice President for
Governmental Relations

cc: Allan W. Ostar
Irene Spero
Polly Gault

Senator SCHWIEKER. Our Health and Scientific Research Subcommittee stands in recess.

[Whereupon, at 11:15 a.m., the subcommittee adjourned, subject to the call of the Chair.]

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