NATIONAL SCIENCE FOUNDATION AUTHORIZATION LEGISLATION, 1977

HEARINGS

BEFORE THE

SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH

OF THE

COMMITTEE ON HUMAN RESOURCES
UNITED STATES SENATE

NINETY-FIFTH CONGRESS

FIRST SESSION

ON

PROPOSED AUTHORIZATIONS FOR THE NATIONAL SCIENCE FOUNDATION FOR FISCAL YEAR 1977

MARCH 1 AND 3, 1977

Printed for the use of the Committee on Human Resources

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CONTENTS

CHRONOLOGICAL LIST OF WITNESSES

TUESDAY, MARCH 1, 1977

Page

Atkinson, Dr. Richard C., Acting Director, National Science Foundation, accompanied by Dr. Norman Hackerman, president, Rice University, and Chairman, National Science Board; Dr. William A. Nierenberg, director, Scripps Institution of Oceanography, and vice chancellor for Marine Sciences, University of California, National Science Board; Dr. Edward C. Creutz, Acting Deputy Director for NSF and Assistant Director for Mathematical and Physical Science and Engineering, NSF; Dr. Eloise E. Clark, Assistant Director for Biological, Behavioral, and Social Sciences, NSF; Dr. Alfred J. Eggers, Assistant Director for Research Applications, NSF; Dr. Jack T. Sanderson, Director, Office of Planning and Resources Management, NSF; Eldon D. Taylor, Assistant Director for Administration, NSF; and Dr. Edward P. Todd, Acting Assistant Director for Astronomical Atmospheric, Earth, and Ocean Sciences, NSF 8

THURSDAY, MARCH 3, 1977

Posvar, Dr. Wesley W., chancellor, University of Pittsburgh, Pittsburgh, Pa., on behalf of the Association of American Universities, American Council on Education, and National Association of State Universities and Land Grant Colleges; T. R. Williams, professor of chemistry, College of Wooster, Wooster, Ohio, on behalf of Great Lakes Colleges Association, Associated Colleges of the Midwest, American Association of State Colleges and Universities, and National Association of Independent Colleges and Universities; Lillie K. Singleton, institute associate, institute of Higher Education Research and Services, University of Alabama, on behalf of the American Association of Junior Colleges; and William M. Jackson, professor of chemistry, Howard University, Washington, D.C., on behalf of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, a panel of the National Science Foundation and Academic Community 147

Barger, James E., chief scientist, Bolt, Beranek & Newman, Inc., Cambridge, Mass.; E. J. Johnson, G.T.E. Laboratories, Inc., Waltham, Mass.; and Arthur S. Iberall, president, General Technical Services, Inc., Upper Darby, Pa., a panel of the National Science Foundation and the industrial community 206

Boasberg, Tersh, senior partner, Boasberg, Hewes, Finkelstein & Klores, attorneys at law, Washington, D.C.; and James B. Sullivan, Ph. D., codirector, Center for Science in the Public Interest, Washington, D.C., a panel of the National Science Foundation and the public 304

Rich, Dr. Alexander, William Thompson Sedgwick professor of biophysics, Massachusetts Institute of Technology, member, National Science Board 318

STATEMENTS

American Association of Community and Junior Colleges, Lillie King Singleton, institute associate, University of Alabama, Institute for Higher Education Research and Services, on behalf of, prepared statement 181

	Page
American Association of State Colleges and Universities, Associated Colleges of the Midwest, Great Lakes Colleges Association, and National Association of Independent Colleges and Universities, Dr. T. R. Williams, professor of chemistry, College of Wooster, on behalf of, prepared statement	168
American Council on Education, Association of American Universities and National Association of State Universities and Land-Grant Colleges, Wesley W. Posvar, chancellor, University of Pittsburgh, on behalf of, prepared statement	153
American Mathematical Association of Two Year Colleges, Dr. Joseph E. Cicero, president, Clayton Junior College Morrow, Ga., prepared statement (with attachments)	325
Supplemental statement	356
Atkinson, Dr. Richard C., Acting Director, National Science Foundation, accompanied by Dr. Norman Hackerman, president, Rice University, and Chairman, National Science Board; Dr. William A. Nierenberg, Director, Scripps Institution of Oceanography, and Vice Chancellor for Marine Sciences, University of California, National Science Board; Dr. Edward C. Creutz, Acting Deputy Director for NSF and Assistant Director for Mathematical and Physical Science and Engineering, NSF; Dr. Eloise E. Clark, Assistant Director for Biological, Behavioral, and Social Sciences, NSF; Dr. Alfred J. Eggers, Assistant Director for Research Applications, NSF; Dr. Jack T. Sanderson, Director, Office of Planning and Resources Management, NSF; Eldon D. Taylor, Assistant Director for Administration, NSF; and Dr. Edward P. Todd, Acting Assistant Director for Astronomical, Atmospheric, Earth, and Ocean Sciences, NSF	8
Barger, James E., chief scientist, Bolt, Beranek & Newman, Inc., Cambridge, Mass.; E. J. Johnson, G.T.E. Laboratories, Inc., Waltham, Mass.; and Arthur S. Iberall, president, General Technical Services, Inc., Upper Darby, Pa., a panel of the National Science Foundation and the Industrial Community	206
Prepared statement	209
Boasberg, Tersh, senior partner, Boasberg, Hewes, Finkelstein & Klores, attorneys at law, Washington, D.C., and James B. Sullivan, Ph. D., codirector, Center for Science in the Public Interest, Washington, D.C., a panel of the National Science Foundation and the public	304
Bolt, Beranek and Newman, Inc., Dr. James E. Barger, chief scientist, prepared statement	209
Center for Science in the Public Interest, James B. Sullivan, Ph. D., codirector, prepared statement	308
General Technical Services, Inc., A. S. Iberall, president and chief scientist, prepared statement	247
Kennedy, Hon. Edward M., a U.S. Senator from the State of Massachusetts, prepared statement	5
Lempicki, A., scientist, and E. J. Johnson, scientist, prepared statement	225
National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, Dr. William M. Jackson, member, board of directors, prepared statement	197
Posvar, Dr. Wesley W., chancellor, University of Pittsburgh, Pittsburgh, Pa., on behalf of the Association of American Universities, American Council on Education, and National Association of State Universities and Land Grant Colleges; T. R. Williams, professor of chemistry, College of Wooster, Wooster, Ohio, on behalf of Great Lakes Colleges Association, Associated Colleges of the Midwest, American Association of State Colleges and Universities, and National Association of Independent Colleges and Universities; Little K. Singleton, institute associate, Institute of Higher Education Research and Services, University of Alabama, on behalf of the American Association of Junior Colleges; and William M. Jackson, professor of chemistry, Howard University, Washington, D.C., on behalf of the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers, a panel of the National Science Foundation and Academic Comunity	147
Prepared statement	153
Rich, Dr. Alexander, William Thompson Sedgwick, professor of biophysics, Massachusetts Institute of Technology, member, National Science Board	318
Biographical sketch of	319

ADDITIONAL INFORMATION

Page

Articles, publications, etc.:
- Academic Fleet Status — 114
- Atkinson, Dr. Richard C., Acting Director, National Science Foundation, biographical sketch of — 9
- Basic Research Funded by the National Science Foundation — 104
- Ethics and Values in Science and Technology (EVIST) — 83
- Hackerman, Dr. Norman, president, Rice University, and chairman, National Science Board, biographical sketch of — 12
- Impact of ARGO Merchant Oil Spill — 20
- International Cooperative Programs: Some Recent Achievements — 87
- National Science Foundation Budget in Brief, fiscal year 1978 — 34
- Nierenberg, Dr. William A., director, Scripps Institution of Oceanography, biographical sketch of — 10
- Oil-Spill Technology — 20
- Research in Industry, Roles of the Government and the National Science Foundation, by A. S. Iberall, president, General Technical Services, Inc — 287
- Statisticians Play Numbers Game, by Ron Taylor, from the Atlanta Journal, Aug. 27, 1975 — 354
- Stats Course Believed 30 Percent Better To Be Taught, by Chuck Bell, from the Atlanta Constitution, Aug. 28, 1975 — 353
- Two-year Authorization for the National Science Foundation — 117

Communications to:
- Atkinson, Richard C., Acting Director, National Science Foundation, from Robert E. Hampton, Chairman, United States Civil Service Commission, Dec. 30, 1976 (with attachments) — 122
- Javits, Hon. Jacob K., a U.S. Senator from the State of New York, from H. Guyford Stever, Director, National Science Foundation, May 17, 1976 — 118
- Pell, Hon. Claiborne, a U.S. Senator from the State of Rhode Island, from E. Creutz, Acting Director, National Science Foundation, Apr. 4, 1977 — 107
- Strauss, Ms. Anne G., professional staff member, from Arthur S. Iberall, president, General Technical Services, Inc., Mar. 11, 1977 — 286

Questions and answers:
- Senator Griffin's questions to Dr. Creutz, with responses — 92
- Senator Kennedy's questions to Dr. Atkinson, with response regarding appropriate technology — 28
- Senator Kennedy's questions to A. S. Iberall, with responses — 285
- Senator Pell's questions to Dr. Creutz, with responses — 109

NATIONAL SCIENCE FOUNDATION AUTHORIZATION LEGISLATION, 1977

TUESDAY, MARCH 1, 1977

U. S. SENATE,
SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEACH
OF THE COMMITTEE ON HUMAN RESOURCES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:15 a.m. in room 4232 Dirksen Senate Office Building, Senator Edward M. Kennedy (chairman of the subcommittee), presiding.

Present: Senators Kennedy, Javits, and Chafee.

Senator KENNEDY. We will come to order.

I am pleased to open the hearings today on the National Science Foundation budget request for fiscal year 1978. I will make some brief comments and include the full text of my statement in the record.

OPENING STATEMENT OF SENATOR KENNEDY

These hearings are being conducted by the Subcommittee on Health and Scientific Research of the Senate Committee on Human Resources. This subcommittee will carry out the responsibilities previously assigned separately to the Health Subcommittee and the National Science Foundation Subcommittee.

I believe that this new structure will enable us to address more comprehensively than in the past the full range of issues which affect Federal support for scientific research. Peer review, public participation, the balance between basic and applied research and the need for long-range planning, priority and policy setting are matters of concern to all Federal agencies engaged in scientific research, to the entire scientific community, and to the public which pays the bills, and is impacted by the results.

We intend to use this new structure as a step to bring greater coherence to Federal policies in these areas, particularly as those policies affect the National Institutes of Health and the National Science Foundation.

This morning we will hear testimony from officials of the National Science Foundation.

On Thursday, we will hear from three panels of public witnesses. And while our primary focus will be the budget of the National Science Foundation, we want to keep in mind the relevance of many of the issues which will arise to the full agenda of legislation which will be coming before this subcommittee during the 95th Congress.

The NSF request this year totals $885 million. Taking into account carryovers from previous years, the request provides an increase of $87.1 million over the Foundation's program for fiscal year 1977.

The request reflects the decision of the new administration to encourage during fiscal year 1978 a real growth of about 3 percent in total Federal support of basic research, an area in which there has been a 19 percent decline, measured in constant dollars, over the last 10 years.

While it is difficult to tie specific economic and social changes directly to research investments, there is much evidence that U.S. science has had an overwhelmingly positive impact on society. A recent survey found that 75 percent of our population believes science and technology have changed life for the better.

Good arguments can be made for increased research funding because support in constant dollars declined seriously for several years prior to 1977.

At the same time, costs rose because of inflation. There is also a need for increased funding for science education programs and for programs which assist the public in dealing with the scientific and technical aspects of policy issues.

I believe the decision on whether the National Science Foundation's budget is adequate must be based upon what society expects of U.S. science to strengthen America. In short, the decision must depend on whether the budget presented will accomplish that goal.

This subcommittee will carefully examine the full range of NSF budget proposals. We will also carefully consider the need for a multiyear authorization for the National Science Foundation.

It is my own firm conviction that such an authorization would provide a framework for program planning that would bring increased stability to the Foundation's planning processes. It would permit the National Science Foundation and the Congress to focus more attention on areas where new programs or projects are being proposed and are deemed to be sufficiently urgent to warrant special authorization.

We will examine also policy issues many of which have been of concern over a long period of time, and some of which have arisen in the past year.

These include some I would like to mention briefly:

(1) Building a broad base of support for increased funding for basic research.

I think if we are serious about insuring the public support for this program, it is important that the public really understand the importance and the relevance of basic research to the quality of life, and its importance to our society. I am not sure we have done all we should have in that area of endeavor, and as one who believes strongly in the importance of basic research, I think this is something we are going to have to look at;

(2) The need to improve our ability to address the ethical and value issues associated with science and technology. This is an extremely important issue. We have attempted to try to address it in the health area, in the protection of human subjects legislation, the importance of consent—informed consent.

We have seen a number of different public policy questions where this has come up—the whole immunization program, for example, with killed and live vaccines and the ethical implications. Another obvious and visible one is the issue of DNA research. There are some important questions here and they tie into our additional responsibilities in the OTA area. We are very much concerned about this.

(3) The need to provide concerned citizens with understandable information on the scientific and technical aspects of policy issues: What is really being done by the NSF to translate complex difficult scientific issues into terms that the lay person can understand.

With all of this, we may need interpreters for the lay society. There must be ways in which that can be done more effectively. People want to know; they have every right to know. It is an important responsibility within the scientific community that they help guide us and advise us so that we can understand these issues more comprehensively. Obviously this is something I would hope the National Science Board and the NSF would give some thought to.

(4) The need to strengthen NSF international programs. There are profound implications and opportunities in the international field, not only in the international health field. For example, in the energy field, where rather significant oil discoveries have taken place in Mexico. Some believe that the full implications of those discoveries have not been realized; and yet, as I understand it in reading through the reports of the President of Mexico's visit here, there exist technical and technological problems that our countries could work on together.

What are we doing in this area of the international program?

I think the national implications are obvious. I represent a State that has profound energy problems. Obviously we have serious problems at the national level. What are we doing? What restrictions are placed upon energy development either through existing legislation, or regulations that have been established. What has been considered by the NSF in the past in this area? What has been either approved or disapproved, and why.

(5) The need for forward-looking applied and policy research programs based on priorities which actually reflect national needs. This is self-explanatory.

(6) The need to insure that researchers are monitored, not to the point where freedom of scientific inquiry is impaired, but to the point where we can be assured that scarce research funds are being used effectively and responsibly.

(7) The need for further research in science education, for an end to the virtual halt in innovative programs to improve the quality of science education. I think that is extremely important.

(8) The need to provide new opportunities for young researchers and to provide experienced researchers with access to continuing education.

From my own experience, I have heard expressions of concern that peer review may be a factor in this. Whether it is true or not true, I am not prepared to say; but we need to know if the researchers with the big names, that come from the big institutions, are the ones that get the grants or find it easier to get the grants over younger researchers and less known institutions that may have very important work to do in terms of our national interest.

Does the peer review system established by the NSF favor those well-known researchers, well-known institutions, as compared to younger researchers?

Is there a problem here?

I assume within all of this that the NSF should not be a passive agency. You people are concerned, obviously, about criticism. I think you ought to welcome some of it, because it shows you are doing the job. I do not think quite frankly you are really doing your job unless you get some of this criticism, make changes, innovate, and create in some of these areas.

You ought to be prepared. You ought to be able to get support within the scientific community. The lay community will support the agency if you develop a good relationship by moving into areas which are creative and imaginative and responsive to the public's interest.

(9) The importance of bringing minorities and women, handicapped persons, into careers in science.

We have gone over this issue in the past. We have set some important steps in motion which we are going to follow up on.

(10) The need to broaden membership of the Science Board to include more persons active in scientific research, persons who are nonscientists, and individuals involved in precollege science education.

I think the Board ought to be more responsive in those areas and that this would advance the NSF's programs and goals.

(11) Possible changes in NSF policy with regard to support of basic research in industrial laboratories; and

(12) The need to insure that the NSF exerts the full extent of its leverage on the scientific community to encourage greater opportunities for minorities and women, to encourage greater participation by scientists in public policy debates, and to lead the way in providing opportunities for the public to become involved in the establishment of policies and priorities for science and technology.

[The full text of Senator Kennedy's prepared statement follows:]

OPENING STATEMENT BY SENATOR EDWARD M. KENNEDY, CHAIRMAN SUBCOMMITTEE ON HEALTH AND SCIENTIFIC RESEARCH, AT HEARINGS ON THE NATIONAL SCIENCE FOUNDATION BUDGET REQUEST FOR FISCAL YEAR 1978

I am pleased to open hearings today on the National Science Foundation budget request for fiscal year 1978.

These hearings are being conducted by the Subcommittee on Health and Scientific Research of the Senate Committee on Human Resources. This Subcommittee will carry out the responsibilities previously assigned separately to the Health Subcommittee and the National Science Foundation Subcommittee.

I believe that this new structure will enable us to address more comprehensively than in the past the full range of issues which affect federal support for scientific research. Peer review, public participation, the balance between basic and applied research and the need for long range planning, priority and policy setting are matters of concern to all federal agencies engaged in scientific research, to the entire scientific community, and to the public which pays the bills, and is impacted by the results. We intend to use this new structure as a step to bring greater coherence to federal policies in these areas, particulary as those policies affect the National Institutes of Health and the National Science Foundation.

This morning we will hear testimony from officials of the National Science Foundation. On Thursday, we will hear from three panels of public witnesses. And while our primary focus will be the budget of the National Science Foundation, we want to keep in mind the relevance of many of the issues which will arise to the full agenda of legislation which will be coming before this Subcommittee during the 95th Congress. These hearings will help us develop an authorization for the National Science Foundation which will sustain scientific strength in the major fields of science, support research directed to areas where there is a high potential for scientific benefit or major advances in science, and improve the quality and scope of science education.

The NSF request this year totals $885 million. Taking into account carry-overs from previous years, the request provides an increase of $87.1 million over the Foundation's program for Fiscal Year 1977.

The request reflects the decision of the new Administration to encourage during Fiscal Year 1978 a real growth of about 3 percent in total Federal support of basic research, an area in which there has been a 19% decline in overall federal support, measured in constant dollars, over the last 10 years.

Let me emphasize in this regard that the National Science Foundation is a major source of Federal support for basic research. The agency accounts for 46 percent of the Federal support going to colleges and universities for civilian basic research.

Whether we are concerned about changing climate patterns, the impact of fluorocarbons on the ozone layer, recombinant DNA, or protecting man from environmental hazards, the public and the Congress properly expect the U.S. scientific community to conduct research that will help the Nation deal with these issues. And we expect a great deal more. We want an expanded knowledge base that will insure a steady stream of appropriate, new, and improved technology. We want to stimulate innovation that will improve the quality of life and provide new employment opportunities.

While it is difficult to tie specific economic and social changes directly to research investments, there is much evidence that U.S. science has had an overwhelmingly positive impact on society. A recent survey found that 75% of our population believes science and technology have changed life for the better.

Good arguments can be made for increased research funding because support in constant dollars declined seriously for several years prior to 1977. At the same time, costs rose because of inflation. There is also a need for increased funding for science education programs and for programs which assist the public in dealing with the scientific and technical aspects of policy issues. I believe the decision on whether the National Science Foundation's budget request merits Congressional support must be based upon what society expects of U.S. science to strengthen America. In short, the decision must depend on whether the budget presented will accomplish that goal.

I am pleased to note that the NSF budget provides for a substantial increase for earthquake research. The objective is to make real progress in improving the capability to accurately predict earthquakes and to engineer earthquake resistant structures. The budget also provides for substantial growth in research support in the neural sciences, with potential for improving our ability to deal with brain damage, and there are increases for research aimed at finding ways to make more effective use of resources and to deal with the range of environmental issues. The NSF request also contains much needed increases for the purchase of scientific equipment and instrumentation.

This subcommittee will carefully examine the full range of NSF budget proposals. We will also carefully consider the need for a multi-year authorization for the National Science Foundation. It is my own firm conviction that such an authorization would provide a framework for program planning that would bring increased stability to the Foundation's planning processes. It would permit the National Science Foundation and the Congress to focus more attention on areas where new programs or projects are being proposed and are deemed to be of sufficient urgency to warrant special authorization.

We will also examine policy issues many of which have been of concern over a long period of time, and some of which have arisen in the last year. These include:

(1) the need to build a broad base of support for increased funding for basic research and institutional support, a base which extends beyond the one million persons who make up our scientific and technical workforce and reaches out to non-scientists whose support is vital if we are to continue to provide strong federal support for science and technology;

(2) the need to improve our ability to address the ethical and value issues associated with science and technology, an area in which there are too few well-trained persons and which now receives only $1.4 million dollars in a total federal R&D budget of over $26 billion;

(3) the need to provide citizens groups with assistance to prepare high quality technical studies in a manner which meets stringent tests of scientific objectivity and merit and in a format readily understandable by the general public;

(4) the need to build more effective working relationships between the Department of State and the National Science Foundation and to strenthen the ability of our scientists to pursue international research issues affecting health, agriculture and nutrition - particularly in areas where advances in scientific research can benefit nations in the developing world;

(5) the need to improve our applied and policy research programs so that they reflect needs as perceived by those who will be using the results of the research, so that interdisciplinary projects can be sustained over an extended period of time, and so that the research focuses on future needs and provides early warning for our society of changing conditions;

(6) the uneven manner in which research grants are monitored by the N.S.F. as a result of which some researchers are being so closely directed and are so concerned about future funding that their freedom of scientific inquiry may be impaired, and others so carelessly supervised that there is little or no assurance that scarce research funds are being used effectively and responsibly;

(7) the need for fundamental research in science education and the virtual halt in innovative programs to improve pre-college science education which has taken place at a time when science achievement levels of our students are declining and the need for a sound understanding of science and its impact on society is essential for the young people who will guide our nation's future;

(8) the lack of progress which has been made in providing opportunities for young researchers and for continuing education for experienced scientists and engineers particularly as changes in federal R&D priorities result in economic dislocation and underemployment in the scientific and technical workforce;

(9) the importance of bringing more minorities, women and handicapped persons into careers in science and the need for imaginative, bold, and innovative experimental programs if we are to remedy the present situation in which minorities comprise less than 5% of the scientific and technical workforce, women less than 15% and handicapped individuals are so few as to be virtually unmeasurable.

(10) the need for inclusion in the National Science Board of more persons who are active in scientific research,persons who are non-scientists,and individuals involved in pre-college science education;

(11) the possibility that greater participation by business and industry in federally funded basic research programs could strengthen our scientific and technical base, enable us to draw more effectively on the talents of the 300,000 scientists and engineers who work in industrial laboratories, and provide significant new employment opportunities for the highly skilled workforce being produced by our universities;

(12) the need to ensure that the NSF uses the full extent of its leverage on the scientific community to encourage greater opportunities for minorities and women, to encourage participation by scientists in public policy debates, and to lead the way in providing opportunities for the public to become involved in the establishment of policies and priorities for science and technology.

I look forward to hearing the testimony which will be presented during these hearings and to discussing in greater detail with the witnesses the issues I have outlined. I know that other members of the Subcommittee share many of my concerns and have other matters as well that they would like to raise. The witnesses may have other items they wish to add to the agenda. By the close of the formal hearings on Thursday I believe we will be in an excellent position to examine the full range of proposals and report to the Senate on our findings and recommendations.

Senator KENNEDY. I look forward to the testimony which will be pesented. I know other members of the committee share many of my concerns. We have new members, some new in the Senate and some new in the direct oversight of NSF, and they have other matters that they would like to raise.

The witnesses may have other items they wish to add to the agenda. By the close of the hearings on Thursday, I believe we will be in an excellent position to examine the full range of proposals and to report to the Senate on our findings and recommendations.

Dr. Atkinson, we will start with you.

STATEMENT OF DR. RICHARD C. ATKINSON, ACTING DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. NORMAN HACKERMAN, PRESIDENT, RICE UNIVERSITY, AND CHAIRMAN, NATIONAL SCIENCE BOARD; DR. WILLIAM A. NIERENBERG, DIRECTOR, SCRIPPS INSTITUTION OF OCEANOGRAPHY, AND VICE CHANCELLOR FOR MARINE SCIENCES, UNIVERSITY OF CALIFORNIA, NATIONAL SCIENCE BOARD; DR. EDWARD C. CREUTZ, ACTING DEPUTY DIRECTOR FOR NSF AND ASSISTANT DIRECTOR FOR MATHEMATICAL AND PHYSICAL SCIENCE AND ENGINEERING, NSF; DR. ELOISE E. CLARK, ASSISTANT DIRECTOR FOR BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES, NSF; DR. ALFRED J. EGGERS, ASSISTANT DIRECTOR FOR RESEARCH APPLICATIONS, NSF; DR. JACK T. SANDERSON, DIRECTOR, OFFICE OF PLANNING AND RESOURCES MANAGEMENT, NSF; ELDON D. TAYLOR, ASSISTANT DIRECTOR FOR ADMINISTRATION, NSF; AND DR. EDWARD P. TODD, ACTING ASSISTANT DIRECTOR FOR ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES, NSF

Dr. ATKINSON. Senator Kennedy, there are two members of the National Science Board here.

To my left is Dr. Hackerman, president of Rice University and Chairman of the National Science Board.

To his left is Dr. William A. Nierenberg, director, Scripps Institution of Oceanography, and also vice chancellor for marine sciences at the University of California.

[The biographical sketches of Dr. Atkinson, Dr. Hackerman, and Dr. Nierenberg follow:]

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

DR. RICHARD C. ATKINSON
Acting Director

Dr. Richard C. Atkinson was sworn in on June 2, 1975, as Deputy Director of the National Science Foundation; on August 12, 1976, he became Acting Director. He is on leave of absence from Stanford University where he has been on the faculty since 1956.

Dr. Atkinson is an experimental psychologist and applied mathematician whose research has been concerned primarily with experimental and theoretical analyses of memory and cognition. He was one of the first to transform intuitive ideas about the nature of memory into an explicit theory that could be formulated in mathematical terms. This theory has been the basis for much of the current research on memory and cognition. The theory also has played an important role in specifying correlates between brain structures and psychological phenomena, in explaining the effects of drugs on memory, and has proved to have important implications for optimizing the learning process.

Dr. Atkinson's research on memory has led him to be concerned with problems of classroom learning. He was among the first to develop a computer-controlled system for instruction, whose basic features have had wide influence on the computer field and have been used in the design of commercial computer-assisted instruction programs. The principal application of the computer system developed by Dr. Atkinson has been for teaching reading to elementary school children. The system is highly adaptive so that the sequence of instruction at any moment in time is a function of the student's unique response history. The adaptive process depends on a mathematical representation of the student's learning process that is optimized using control theory methods.

He is a member of the National Academy of Sciences, the American Academy of Arts and Sciences, the National Academy of Education, and the Society of Experimental Psychologists. He has been a Fellow of the Center for Advanced Study in the Behavioral Sciences, a Fellow of the Guggenheim Foundation, and the recipient of a Distinguished Research Award from the Social Sciences Research Council.

Dr. Atkinson joined the Stanford University faculty in 1956 after serving in the U.S. Army. Except for three years at UCLA and one at the University of Michigan, he has been at Stanford ever since. He served as chairman of the Psychology Department from 1968 to 1973, and as a Dean in Humanities and Sciences from 1973 to 1975. In addition to being a Professor in the Psychology Department, he holds appointments in the School of Engineering, the School of Education, and the Institute for Mathematical Studies in the Social Sciences.

October 7, 1976

WILLIAM A. NIERENBERG

Dr. William A. Nierenberg is Director of Scripps Institution of Oceanography and Vice Chancellor for Marine Sciences of the University of California, San Diego. He has been associated with the University of California since 1950.

Primarily known for his work in low-energy nuclear physics as Professor of Physics at Berkeley and at the University's Lawrence Radiation Laboratory, Berkeley-Livermore, he has established himself as a leading expert in the field of underwater research and warfare.

He served in Paris as Assistant Secretary General of NATO for Scientific Affairs 1960-62, and at the same time was Professeur Associé at the University of Paris.

On the national level he has served on various panels of the President's Science Advisory Committee, and has been consultant to the Navy, National Security Agency, National Research Council's Mine Defense Advisory Committee, Institute for Defense Analyses, and Department of Defense. He has just been appointed senior consultant to the newly formed White House Office of Science and Technology Policy.

He was born in New York City in 1919. He attended the University of Paris 1937-38, returning home to receive his B.S. degree from the City College of New York in 1939. He received his Master's degree in 1942 and Ph.D. degree in 1947 in physics from Columbia. From 1942 to 1945 he was a section leader on the Manhattan Project.

He has directed productive research in the field of atomic beam measurements of electronic and nuclear properties of radioactive atoms, and has authored or co-authored more than 100 publications in this field.

Among his current affiliations, he is a member of the Space Applications Board, National Academy of Engineering, National Science Board; Past Chairman (1971-75) and member of NACOA; member of Marine Science Sub-Committee of the Advisory Committee on Law of the Sea; Adviser-at-large to the Department of State.

He is a member of the National Academy of Sciences, American Philosophical Society and the American Academy of Arts and Sciences.

In 1958 he was selected as the first E. O. Lawrence Memorial Lecturer by the National Academy of Sciences. He was recipient of the Golden Dolphin Award of the Association Artistico Letteraria Internazionale (1968) of Florence. He was awarded the medal of "Officier de l'Ordre du Merite" from the Government of France. In 1975 he was a recipient of the Compass Award of the Marine Technology Society.

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NORMAN HACKERMAN

BIOGRAPHICAL DATA

Full name:	Norman Hackerman
Address:	President's House, Rice University, Houston, Texas 77001
Date of birth:	March 2, 1912
Place of birth:	Baltimore, Maryland
Education:	A. B., Johns Hopkins University, 1932
	Ph. D., Johns Hopkins University, 1935
Honorary degrees:	LLD, St. Edwards University, 1972
	D. Sc., Austin College, 1975

Positions held:

Rice University	
President	1970-
Professor of Chemistry	1970-
The University of Texas at Austin	
President	1967-70
Vice Chancellor for Academic Affairs	1963-67
Vice President and Provost	1961-63
Dean of Research and Sponsored Programs	1960-61
Director of the Corrosion Research Laboratory	1948-61
Chairman of the Chemistry Department	1952-61
Professor of Chemistry	1950-70
Associate Professor of Chemistry	1946-50
Assistant Professor of Chemistry	1945-46
Research Chemist, Kellex Corporation	1944-45
Assistant Professor of Chemistry, Virginia Polytechnic Institute	1941-43
Assistant Chemist, United States Coast Guard	1939-41
Research Chemist, Colloid Corporation	1936-40
Assistant Professor of Chemistry, Loyola College	1935-39

Memberships in Learned Societies

Elected member of the American Philosophical Society	1972
Elected member of the National Academy of Sciences	1971

Electrochemical Society (Chairman, Corrosion Division, 1951; Vice President, 1954-57; President, 1957-58; Interim Editor, Electrochemical Technology, 1965-68; Technical Editor, Journal of the Electrochemical Society, 1950-68; Editor, 1969-) Honorary Member, 1973.

Memberships in Learned Societies (continued)

American Chemical Society (Executive Committee, Colloid Division, 1955-58; Board of Editors, American Chemical Society Monograph Series, 1956-62) Honorary Member, 1975

National Association of Corrosion Engineers (Board of Directors, 1952-55; Chairman, A. B. Campbell Young Authors Award Committee, 1960-)

Intersociety Corrosion Committee (Chairman, 1956-58)

Fellow, American Association for the Advancement of Science

International Society of Electrochemistry

Memberships on Boards, Committees, and Councils

Board on Energy Studies of National Academy of Sciences/National Research Council; chairman, 1974-

National Board on Graduate Education, 1971-75

National Science Board, 1968- ; chairman, 1974-

Argonne National Laboratory (Chemical Engineering Division Review Committee, 1963-69; chairman, Board of Trustees, 1969-73)

Gordon Research Conferences (chairman, Conference on Corrosion, 1950; chairman, Conference on Chemistry at Interfaces, 1959; member, Board of Trustees, 1970-73)

Universities Research Association (Council of Presidents); chairman, 1973

Environmental Pollution Panel, the President's Science Advisory Committee, 1965-66

Industry Consultant to the Metal Surface Treatment Equipment Show, Stockholm Trade Center, for U. S. Department of Commerce, 1967

Association of Universities for Research in Astronomy, Inc. (Consultant, 1964-)

Editorial Board, Catalysis Reviews, 1968-73

Advisory Editorial Board, Corrosion Science, 1965-

Oak Ridge Associated Universities; Board of Directors, 1975-

Who's Who in America; Board of Advisors, 1975-

Awards

Whitney Award of National Association of Corrosion Engineers	1956
Joseph L. Matticllo Award	1964
Palladium Medalist of the Electrochemical Society	1965
Southwest Regional Award of the American Chemical Society	1965
Honor Scroll, Texas Institute of Chemists	1975

Honorary Societies

Alpha Chi Sigma
Phi Kappa Phi
Phi Lambda Upsilon
Sigma Xi

Important Publications*

N. Hackerman and R. A. Powers, J. Phys. Chem., 57, 139 (1953), "Surface Reactions of Chromium in Dilute $Cr^{51}O_4$ Solutions."

A. C. Makrides and N. Hackerman, Ind. Eng. Chem., 46, 523 (1954), "Action of Polar Organic Inhibitors in Acid Dissolution of Metals."

W. H. Wade and N. Hackerman, Trans. Faraday Soc., 53, 1636 (1957), "Anodic Phenomena at an Iron Electrode."

P. V. Popat and N. Hackerman, J. Phys. Chem., 62, 1198 (1958), "Capacity of the Electrical Double Layer and Adsorption at Polarized Platinum Electrodes. I. Adsorption of Anions."

N. Hackerman, Z. fur Elektrochemie, 62, Nr. 6/7, 632 (1958), "Sorption, Oxidation and Passivity."

E. S. Snavely, Jr. and N. Hackerman, Can. J. Chem., 37, 268 (1959), "The Anodic Passivation of Iron."

N. Hackerman, J. Electrochem. Soc. (India), VIII (1), 9 (1959), "Corrosion Inhibition and Chelating Agents."

N. Hackerman, Comptes Rendus du Symp. Eur. sur les Inhibiteurs de Corrosion, Ferrara, Italy, 1960, "An Adsorption Theory of Corrosion Inhibition by Organic Compounds."

N. Hackerman and R. M. Hurd, First Int. Cong. on Metallic Corrosion, London, 1961, "Corrosion Inhibition and Molecular Structure."

N. E. Wisdom, Jr. and N. Hackerman, J. Electrochem. Soc., 110, 318 (1963), "Surface Studies on Passive Iron."

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*Dr. Hackerman is the author and co-author of more than 170 publications. The publications listed are among the more important ones.

Important Publications (continued)

W. H. Wade and N. Hackerman, Advances in Chem. Series, 43, 222 (1964), "Thermodynamics of Wetting of Solid Oxides."

N. Hackerman and W. H. Wade, J. Phys. Chem., 69, 314 (1965), "A Microcalorimetric Study of Liquid-Liquid Displacement Phenomena."

R. M. Hurd and N. Hackerman, Electrochimica Acta, 9, 1633 (1964), "Passivity Phenomena at the Silicon/Electrolyte Interface."

N. Hackerman, E. S. Snavely, Jr., and J. S. Payne, Jr., J. Electrochem. Soc., 113, 677 (1966), "Effects of Anions on Corrosion Inhibition by Organic Compounds."

D. M. Mohilner and N. Hackerman, Electrochimica Acta, 11, 1669 (1966), "Thermodynamic Treatment of Interfacial Curvature in Electrocapillarity."

N. Hackerman, E. S. Snavely, Jr., and L. D. Fiel, Electrochimica Acta, 12, 535 (1967), "Anodic Passivity of Nickel in Hydrogen Fluoride."

K. Kawasaki and N. Hackerman, Japanese Journal of Applied Physics, 6, 1184 (1967), "Vapor Adsorption and Displacement on Porous Glass by Surface Conductivity."

K. Aramaki and N. Hackerman, J. Electrochem. Soc., 115, 1007 (1968), "Structure Effects of Many-Membered Polymethyleneimine on Corrosion Inhibition."

K. Aramaki and N. Hackerman, J. Electrochem. Soc., 116, 568 (1969), "Inhibition Mechanism of Medium-sized Polymethyleneimine."

Erwin Laengle and Norman Hackerman, J. Electrochem. Soc. 118, 1273-78 (1971). "Electrode Behavior of Iron in 2M HCl Containing Oximes or Quinuclidine."

H. Vaidyanathan and Norman Hackerman, Electrochim. Acta 16, 2193-2199 (1971). "Further Aspects of the Differential Capacitance of Iron."

D. Larkin, N. Hackerman et al., J. Electrochem. Soc. 119, 189-191 (1972). "Liquid Ammonia as a Non-Aqueous Solvent: The Kinetics of Tb/Tb^{+2} Exchange."

E. McCafferty and N. Hackerman, J. Electrochem. Soc. 119. 999-1009 (1972). "Kinetics of Iron Corrosion in Concentrated Acidic Chloride Solutions."

Kotaro Ogura and Norman Hackerman, J. Electrochem. Soc. 120, 1638-1644 (1973). "The Transient Behavior of Passivated Iron under Cathodic Potential Pulsing."

Dr. ATKINSON. I am pleased this morning to present an overview of the authorization request of the National Science Foundation for fiscal year 1978. We proposed a total program of $885 million, an increase of $87.1 million and 10.9 percent more than the program of the current year.

The new program reflects a decision to press for a real growth, after offsetting inflation, of about 3 percent in total Federal support of basic scientific and engineering research. This continues the effort begun last year to increase U.S. support for basic research.

This increase is proposed for several reasons. Let me mention four:

First, there has been a continuing rise in the cost of research during a period in which the real dollar investment in basic research has declined. The precise impact of inflation on the cost of research is a matter of some debate, but there is general agreement that the impact has been substantial;

Second, there is increasing obsolescence of research instruments and equipment;

Third, there are unusually promising research opportunities in areas such as computer sciences, plant sciences, and chemical processing where scientific breakthroughs could have profound effects on our economy; and

Fourth, advances in biology, engineering, and the Earth sciences are opening new avenues of investigation that are expected to lead to improvements in the agriculture and health and also to reduce risks from earthquakes.

Senator KENNEDY. This subcommittee has been interested in earthquake research for a long time. The Congress has repeatedly recommended a commitment to increased funding in earthquake research.

My colleague on this committee, Senator Cranston, has been particularly interested in this area of research. We have faced some opposition in the past.

Where are we on that? So I can give Senator Cranston a good report.

[Laughter.]

Dr. ATKINSON. I think the plan for the earthquake science is a every excellent one. It has been carefully coordinated with other agencies. The National Science Foundation, along with the U.S. Geological Survey will be the key players in this game.

A scientific committee out of the Office of Science and Technology Policy reviewed the situation. They came up with three levels of expenditure and the level that we are talking about is an intermediate level that in the judgment of the scientific community is the right effort to be made at this point in time.

Senator KENNEDY. Fine.

Proceed.

Dr. ATKINSON. Let me emphasize, Mr. Chairman, that basic scientific research is a critical, but often unrecognized, form of economic investment. It is estimated that more than one-third of the growth in national income during the postwar period flowed from advances in knowledge, particularly in the sciences and the new technologies to which they gave rise.

I would like to turn now to a fuller discussion in the Foundation's program for fiscal year 1978.

In shaping our program, we have sought to continue our efforts in all significant areas of inquiry.

We have also sought to focus additional resources upon areas which could yield important and fundamental new knowledge and to meet some of those concerns and opportunities which I have mentioned.

MATHEMATICAL AND PHYSICAL SCIENCES AND ENGINEERING

We are requesting $249.2 million for mathematical and physical sciences and engineering—an increase of $25.3 million in order to pursue a broad range of opportunities.

In elementary particle physics, we plan to start conversion of the Cornell electron synchrotron into an electron-positron colliding beam device and also to continue substantial support of user groups at other accelerator facilities.

We intend to increase funding of sophisticated new instrumentation, especially lasers, for experiments in chemistry and to support design studies for the construction of a heavy ion facility.

We plan initiatives in our mathematics and computer science programs aimed at using computers more efficiently and improving the problem-solving power of computer software.

There are increases for upgrading and expanding the synchrotron radiation facilities at Standard University and the University of Wisconsin.

In engineering and materials research, we plan to emphasize such areas as communications in the optical wave lengths, catalytic processes, superconducting devices, and the synthesis of crystals and composite material with unique properties.

ASTRONOMICAL, ATMOSPHERIC, EARTH AND OCEAN SCIENCES

We are requesting $213.4 million for the astronomical, atmospheric, Earth and ocean sciences, an increase of $24.6 million above the current year's level.

In astronomy, we are asking increased support for the development of extremely sensitive optical and submillimeter detectors that are superior to the photographic plate traditionally used in astronomy. We also are requesting funding for the support of research projects that will use these facilities.

Increases are proposed in the atmospheric sciences for climate modeling , long-range forecasting, and studies of atmospheric chemistry which include work relevant to man's impact on the protective ozone layer of the stratosphere.

Senator KENNEDY. Of course, you are obviously very much aware of the enormous concern of the public with regard to the severe weather this past winter, and the effect that it has had on the country, on the health and well-being of the people, let alone on the energy situation.

Is there anything you can tell us about our scientific and technical capabilities in predicting climate patterns?

What kind of work do you do in that area?

Dr. ATKINSON. There is a lot to say there, Senator Kennedy. The Foundation has had a rather remarkable history in this area.

About 3 years ago we set up a new program in climate dynamics. We saw some significant opportunities in that program, along with a new program that we set up this year in atmospheric chemistry. There are indications that the scientific community is aware of pending problems and anticipating these problems with appropriate efforts.

Senator KENNEDY. Is it a technological problem, or do we lack the basic knowledge we need to make important breakthroughs? Are we not giving sufficient time and support to the research? Or what is the state of the art, so to speak? How difficult will it be to get some important breakthroughs?

Dr. ATKINSON. I am not an expert here, but I think it is a mixed problem. On the one hand, the necessary theory is still being developed. On the other hand, the necessary data observations that would feed into some of these models has not been available in the past. It is now becoming available. There is a mix between data and theory here that is just beginning to jell. It provides significant promise for the future.

Dr. Todd or Dr. Nierenberg may want to comment further.

Dr. TODD. I think, Senator, the progress in the understanding of climate is quite good, but naturally what is happening at the present time is that progress is being made in understanding the causes of the very large changes. For example, major glacial periods ended about 18,000 years ago. As a result of work both in the atmosphere and in the oceans area we are reaching the stage where we have a good understanding of the causes of those major glacial periods.

When you look at a smaller variation, such as the so-called Little Ice Age of the 17th century, where the Nation experienced a series of quite cold winters, progress is being made, but not quite with the same degree of certainty as to what the causes might be of those. Naturally, then, the smaller the change from normal behavior, the more difficult it is to discern the causes.

I think with respect to this past winter, it really was not a record-breaker, but it was a bit on the cool side compared to the average for the past century. There are some indications that we can expect in the next century or so a somewhat higher frequency of cold winters; but again in terms of past climate changes, it is a rather gentle change; and it is therefore harder to absolutely identify the causes.

Dr. ATKINSON. In the Earth sciences we are placing greater emphasis upon work for understanding earthquake mechanisms and for developing the detailed knowledge required for models to predict the time and place of major Earth movements.

We are seeking increased support of oceanographic field studies, including more detailed analysis of the cores obtained from the deep sea drilling project, and also additional ship and submersible time needed for the conduct of marine studies. NSF provides about 70 percent of the support necessary to maintain and operate the 32 research vessels in the academic fleet.

Funds are also requested to continue on schedule the construction of the very large array, VLA, for radio astronomy.

Senator KENNEDY. We had two NSF research vessels assisting in assessing the damage caused by the *Argo Merchant* oil spill off our coast in New England.

Can someone on the panel tell us a little bit about the work that was done and is being done in attempting to evaluate the long-range impacts that the spill would have?

Dr. ATKINSON. One of those vessels was from Woods Hole, and the other was from the University of Rhode Island. Both are part of the academic fleet.

Dr. Todd is familiar with that story.

Dr. TODD. The Woods Hole Institution, as you perhaps know, has been looking into the ecological effects of oil spills for quite some years. With respect to the *Argo Merchant* disaster, we were lucky in that it occurred at a time when one of the Woods Hole ships was at home as was the new University of Rhode Island ship, which this committee was instrumental in authorizing. These were the ships used to take out some of the Federal teams inspecting the site and to permit scientists to make initial baseline measurements of the spill and its behavior in the days immediately following the spill when the storm winds were blowing it to sea.

Contrary to some of the spills closer to shore, where the petroleum settled rather quickly to the bottom and is still detectable in the marshes, a good deal of this spill stayed on the surface and blew rather rapidly toward the Gulf Stream.

The committee might be interested to know that the new ship at the University of Rhode Island had just recently been dedicated and was at that time undergoing initial tests. It was not yet fully involved in the research program, so the opportunity to use it on the *Argo Merchant* oil spill worked in well with its initial shakedown cruise.

Senator KENNEDY. What are you finding? Do you want to send us a note on that?

Dr. TODD. Perhaps I could amplify that for the record; but the initial findings were that even though it was a period of very intense storms, the oil that was spilled stayed on the surface more completely than had been expected. Therefore, it was moved by the winds. I think we do not yet know the extent to which the oil impacted the bottom in that fish area.

Senator KENNEDY. But they are reviewing that, as I understand it?

Dr. TODD. That is correct, sir; it is being followed closely and monitored every few days.

Senator KENNEDY. A number of pieces of legislation on tanker safety and oil spills have been introduced. I have one and a number of my colleagues, Senator Magnuson and others, have also introduced bills. They deal with the design of tankers, the training of personnel, navigation, and equipment. They provide for monitoring the entry of ships into American waters. There is a provision in most of the bills for research in this whole area.

What do you know about where we are on that? Is there anything you can tell us? Are you working in that area? We are going to be faced, obviously, with a continuing need for imported oil products. We get the equivalent of one *Argo Merchant* landing in Massachusetts every day. We are going to be, whether we like it or not for a continuing period of time, importing this oil and we are going to be faced for the foreseeable future with this kind of problem.

Can you tell us a little bit about the nature of the scientific information in that area of science and technology? Maybe you want to submit something to us later on this.

Dr. ATKINSON. We would like to submit something for the record. I can say we do not have anything at the moment in the RANN directorate.

[The material referred to follows:]

Material for record on impact of ARGO merchant oil spill follows:

Two academic oceanographic institutions--Woods Hole Oceanographic Institution (WHOI) and University of Rhode Island (URI)--have participated in early monitoring of the spill. WHOI carried out two short cruises in late December on the R/V Oceanus involving a total of 4 ship days and the efforts of a total scientific complement of 30. They cooperated with the NOAA Federal Oil Spill Response Team but received no funding from NOAA. WHOI has also sent its small boat Asterias to the spill area several times and several members of the staff have carried out chemical analyses on sediment samples. WHOI's involvement has been quite limited since funds are not available for long-term monitoring. To date they have found oil in the sediments collected in the region of the spill, some of which has been identified as deriving from the Argo Merchant. To date WHOI has not found oil contamination of biological samples.

URI has conducted four cruises on the R/V Endeavor involving 14 days at sea and a total scientific complement of 61. URI received $85,000 from NOAA for field data collecting costs including most of the ship time. NOAA funding has not been available, however, for data analysis. To the extent that this is being carried out, the time and effort of staff is being diverted from other projects. Some sample analyses have been performed by the U.S. Coast Guard Laboratory at Groton, Connecticut, and others, by USCG personnel aboard R/V Endeavor.

An area of approximately 1200 square miles of Nantucket Shoals-Little George's Bank area has been examined for bottom sediment contamination. Traces of oil in the sediments were confined to an area as small as 50 square miles, with only a few stations showing significant contamination. The finding of the presence of oil in the sediments is important since previous studies have shown that fractions of petroleum can persist in the sediments for at least 5 years, perhaps longer, thus affecting the organisms dwelling in or on these sediments on a long term basis.

Several observations were made on board Endeavor relating to the possible effects on the biota of the area. It should be noted that these observations are superficial in character and that future histopathologic and chemical analysis and ecological descriptions will be necessary in order to make final observations. Zooplankton samples were examined microscopically and found to have oil droplets adhering to their appendages and in their digestive tracts. Preliminary Coast Guard screening indicated that the oil droplets were Argo Merchant oil. The two main classes which appeared to be affected were copepods and amphipods. Later laboratory analysis will reveal the percentage of the total population involved. The zooplankton which were visually affected in this way were found to extend over a 120 square mile area in the vicinity of the wreck. The effect of these contaminated organisms on the food chain of the area is presently under study by the National Marine Fisheries Service. Phytoplankton samples were also collected but laboratory work is needed to make even preliminary observations of these organisms.

Conclusive results would require a continued field sampling program for several years accompanied by well-supported laboratory analysis to assess long-term impact.

Material for record on oil-spill technology follows:

NSF's RANN has, in past fiscal years, supported studies related to oil spills, but the Environment Effects of Energy Program has now been terminated since ERDA has assumed this responsibility. Descriptions of several FY 76 RANN projects on spills are appended. No other oil-spill projects are currently funded by NSF.

The U.S. Coast Guard has established a "Federal Oil Spill Strike Force" to meet its responsibility to take the lead in emergency recovery and clean up procedures following an oil spill. Although the Environmental Protection Agency (EPA) presumably has the responsibility under the National Contingency Plan on Oil and Hazardous Materials for Assessment of damages, it appears that NOAA played the central role in the Argo Merchant spill with its sponsorship of a Federal Oil Spill Response Team. A comprehensive report on this spill is currently in preparation by NOAA.

Beach Morphology in Relation to the Distribution of Oil From a Spill in the Straits of Magellan: A Comparison with Potential Spill Sites in New England and Alaska; *Miles O. Hayes;* University of South Carolina 29208; $98,600 for 12 months beginning December 15, 1975.

In August, 1974, the supertanker Metula ran aground in the Straits of Magellan. Nearly 18 million gallons of crude oil spilled into the water and about 80% of that was washed ashore. Brief studies made over a 12-month period from August 1974 to August 1975 indicate that much of the oil washed ashore is still on the beaches—along nearly 100 km of shoreline. Chemical studies indicate that, at least during the first 5 months following the accident, the oil on the beaches underwent little degradation.

The objective of this research is to develop a land-form classification of beaches in the Straits of Magellan and to measure the amounts of oil that has accumulated on the different classes of beaches as a result of oil spills. This information would be useful in predicting the extent of oil spill damage on a particular class of beach. In addition, a study of the beach processes would also indicate changes occurring through wave action.

To date, the beaches have been classified, amounts of oil noted, wave action studied, and over 65 detailed beach profiles measured along 100 km of shoreline. Permanent survey stakes have been set so that changes in beach form can be measured in the future. It has been found in beaches subject to erosion that an important means of oil removal is by wave and current action which actually destroy a part of the beach by removing sediment and oil. The oil is lost to the water and the resulting clean sediment is then washed up onto another beach. On other beaches, the in-place oil is being covered by fresh sediment being washed in from previously eroded beaches. Although this process is understood, the rate at which it occurs is not. Rate information can be obtained by using the survey stakes which were placed along the beaches by the Principal Investigator during the original trip to the beaches in February 1976. In August 1976 the researchers will return to the beaches to measure new beach profiles in order to calculate the rate of beach destruction and build-up in the six months between trips. At this time, beach processes in winter will also be studied. Previous NSF studies have shown that parts of the Straits of Magellan are strikingly similar to coastal areas of New England and Southern Alaska. The rate information obtained by studying the Chilean beaches will provide valuable data pertaining to the New England & Alaskan beaches; such as, the type of damage to expect, the nature of wave processes, and the rate at which wave action will either clean a beach or cover existing oil with fresh sediment.

Because of the expected increase of oil activity (production, refining, transportation, and storage) in N.E. & Southern Alaska, the probability of oil spills in these areas will increase. Information from this research project will provide researchers with data for classifying New England Alaskan beaches on the basis of potential spill damage and will also be useful in the planning of sites for petroleum facilities.

Microbiological Effects of Petroleum Accumulation on Beaches; *Rita R. Colwell;* **University of Maryland, College Park, Maryland 20742; $92,000 for 12 months beginning March 15, 1976.**

This project is part of a broader AENV-sponsored study designed to evaluate the effects of oil which has spilled on different beach types.

The purpose of this study is to evaluate the environmental effects of spilled oil on microorganisms of beaches. This is important and timely research because microorganisms play a vital role in the life cycle of higher animals and plants; and because their destruction can result in plant loss which, in turn, reduces the stability of beaches. In addition, microorganisms contribute significantly in degrading spilled oil, thus providing a natural means of clean-up after a spill.

The research plan involves the collection of sediment and water samples and (1) measuring the effect of oil on microorganism populations; (2) evaluating effects of oil on oil-degrading bacteria by monitoring bacteria during degradation of a control oil; and (3) assessing the potential for bacteria to degrade oil by inoculating oil samples with organisms and analyzing organic extracts as a function of time. These factors will be evaluated for their relevance to different types of beaches in the spill area, resulting in the information necessary to rate or rank beaches on the basis of beach type in terms of potential for damage to microorganisms and potential for degradation of the spilled oil.

Physico-Chemical Reactions of Metals in Petroleum With Beach Sediment; *Joseph H. Rule;* **Department of Geological Sciences, University of Tennessee, Knoxville, Tennessee 37916; $56,300 for 15 months beginning June 1, 1976.**

This research project is closely related to two other NSF-funded studies which were prompted by the large oil spill that occurred in August 1974 in the Straits of Magellan. In that spill, nearly 18 million gallons of crude oil was lost, and about 80% of that oil as washed up on to the beaches. Subsequent studies show that much of the oil is still there.

The emphasis of this project is on studying the physical-chemical interaction between oil and beach sediment, particularly on the partitioning of heavy metals between oil and sediment. The distribution of oil in terms of sediment type will also be studied.

This research is desirable for two reasons: 1) the presence of metals plays a vital role in the productivity of oil-degrading bacteria; and 2) heavy metals may have a profound effect on nutrients in soil which would affect plant growth and subsequent beach stability. An end product of the research is to define biological and physico-chemical effects of oil in terms of beach type so that results can be applied to similar beach types in other areas. For this reason, study of the Chilean beaches is especially valuable because of the similarity of the Chilean beaches to New England and southern Alaskan beaches—areas of the United States likely to experience a considerable increase in petroleum activity in the not-too-distant future.

The goals of this research will be accomplished by studying samples in one small area of the Straits which serves as a microcosm of the entire region. This area, the Punta Anegada, comprises a number of different types of beach sediment, all of which have been heavily inundated by oil.

Computer Model for Oil Spill Movement in Delaware Bay; *Robert B. Biggs;* **College of Marine Studies, University of Delaware, Newark, Delaware 19711; $186,600 for 12 months beginning April 1, 1976.**

This is a continuance of an 18-month project originally funded by NSF in FY 1974. The Lower Delaware Bay is the site of an extensive transfer of crude oil from large tankers to small vessels. Frequently, small spills occur, and the potential for a massive spill is always present. The objective of this study is to develop a computer model which predicts the 2-dimensional movement of an oil spill in Delaware Bay in terms of locations and time. The computer model will predict oil movement in relation to current and wind conditions, bottom topography, size of spill, and viscosity of oil. This capability allows for the efficient placing of equipment during a clean-up operation. In addition, the model will show where a spill is likely to migrate during a given season of the year, thus indicating where, along the shoreline, clean-up equipment should be stored for the most advantageous use.

The goals for the remaining year of the study are to: (1) incorporate into the model severe wind conditions and the behavior of frontals; (2) complete water-oil emulsification studies; and (3) complete remote sensing studies for the purpose of tracking the spills and validating the study. In addition, different ways of handling incoming oil shipments in the Lower Delaware Bay will also be evaluated.

Dr. ATKINSON. On the other hand, there are a number of leads, particularly related to recombinant DNA work that are very promising with regard to oil spills.

Dr. Clark may want to expand on that. There are some basic research thrusts that are under way now that are quite promising.

Do you want to describe the R. & D. recombinant work?

Dr. CLARK. These findings are related to the recombinant DNA technology work; but, instead, the investigators have used a series of natural plasmids and natural mutants of the bacterial *pseudomonad* strain to construct organisms that are capable of disgesting the hydrocarbons of oil and converting them into protein. The impact that these organisms might have on environmental situations remains to be ascertained; but the findings offer very promising leads in terms of providing a natural way of controlling the impact of an oil spill.

Senator KENNEDY. Dr. Nierenberg, would you like to make any comments?

Dr. NIERENBERG. One general one.

We know a fair amount, particularly from work at Woods Hole. There is a group there that has worked on this problem for many years, long before it became popular. There is also one at the University of California, Berkeley at Bodega Bay. We really know a good deal about some aspects of this problem.

The difficulty, sir, is that when we use the words "oil tanker spills" we are really talking about something very variable. There are many different fractions that are carried by ships, some of them very volatile, that disappearing very rapidly; I can say to the extent we are discussing it, with very little effect on the environment.

Others are very heavy, residual fractions that go through chemical reactions with which I am not totally familiar.

My colleague, Dr. Hackerman, on the right could explain the chemical details. These have long-term residual effects that we are deeply concerned about. In simple language, an oil spill, on the average, is a temporary tragedy for the locality.

Generally speaking, the locality will recover in time. I say "generally." I can invent a situation where the local damage will be more permanent. What we are concerned about, however, is some of the very long-term effects right now of oil spills. That is why the question about residuals comes up so importantly as an example. Here, as in many other problems of social importance, we are in a good half-way but not totally satisfactory position as to needed knowledge.

Dr. HACKERMAN. May I interrupt to point out that what Dr. Clark has just told you is a fine example of research done in one area and applied elsewhere without any prior understanding that that would be the case.

The fact that these mutants may indeed digest the hydrocarbon-protein is very important. But it had nothing to do with petroleum to begin with.

Senator KENNEDY. OK.

BIOLOGICAL, BEHAVIORAL AND SOCIAL SCIENCES

Dr. ATKINSON. For the biological, behavioral and social sciences, we seek $144.8 million, an increase of $18.2 million over the current year's funding.

We are stressing fundamental studies in the plant sciences, especially the processes of photosynthesis and nitrogen fixation. Better understanding of these processes could lead to significant advances in agriculture. In the behavioral area, we want to take advantage of recent advances in instrumentation to deepen our understanding of how nerve impulses are transmitted, how nerve networks are organized in the brain, and how these networks control learning and other higher order cognitive processes. We also want to understand more about the regulatory interactions of organisms in natural ecosystems.

Senator KENNEDY. You have, as I understand it, some $800,000 set aside for efforts to improve DNA research facilities; is that correct?

Dr. ATKINSON. That is correct.

Senator KENNEDY. That is a matter of enormous importance and public concern.

Is that enough in that area? What did you request?

Dr. ATKINSON. I have the figure here.

It is closer to $800,000 in the 1978 budget. A key aspect of our NSF budget for 1978 is instrumentation and improvement of facilities; and so it is double that figure. In 1978 we plan to support conversion of approximately 20 laboratories that would be involved in what is called moderate-risk research and some 40 laboratories which would be involved in what is called low-hazard risk.

Senator KENNEDY. You basically use that to give advice to various institutions, do you?

Dr. ATKINSON. Those funds will be actually made available for construction and renovation purposes.

Senator KENNEDY. Is it not technical assistance? You are not actually improving the facility, are you?

Dr. ATKINSON. No. We will be providing the funds for construction of the facility or the modification of a facility.

Senator KENNEDY. How are you going to do it? How far can $800,000 go in terms of those various facilities?

Dr. ATKINSON. Dr. Clark is the expert here.

Dr. CLARK. If I could clarify, we first of all do not expect to provide funds for any of the laboratories that are in the so-called high-risk category, so that the bulk of our funds will go toward improving existing laboratories to bring them in line with current standards as specified in NIH guidelines.

It turns out that for many laboratories to bring them into line for the so-called P–2 level of containment, which is the minimum risk level, many of the conversions can be done for something on the order of $10,000. It is just a matter of adding appropriate safety cabinets or some particular filtering device or some other special feature.

For converting or equipping a P–3 lab, that might take on the order of $100,000 to $200,000. We would expect to fund some of these facilities; but we also know that the National Institutes of Health has a significantly larger investment, so that they will be sharing the costs of this improvement of facilities.

Senator KENNEDY. We want to welcome Senator Chafee, who is a member of our commitee.

We were talking very constructively and favorably about the Rhode Island situation where we had the NSF research vessels based. We were discussing the work they did after the *Argo Merchant* oil spill off the New England coast.

Senator CHAFEE. The mere mention of that brought me right up here in a hurry.

Senator KENNEDY. Very good.

What actually did you request; can you tell us what you requested from OMB in this area?

Dr. CLARK. In recombinant DNA research?

Senator KENNEDY. Yes. There was not any specific request; it was part of the total, was it?

Dr. CLARK. We indicated to them, because of the new opportunities available with recombinant DNA research and because of the need to make sure that labs that were carrying out this research were doing so under proper conditions, that provisions were included in our initial planning; and our planning level request was essentially granted.

I shall have to check details for the record, since we also submitted a higher level request that included additional opportunities beyond the planning level. This was not granted. Perhaps Dr. Sanderson would have the information.

[The information referred to follows:]

The base budget request to OMB for containment facilities for biohazardous research projects are likely to include amounts for recombinant DNA research met by the base budget included $7.3 million for additional instrumentation, plant sciences, and membrane research but did not identify specifically those portions for recominant DNA research or containment facilities. $1.6 million of the $7.3 million additional requested was provided in the President's budget primarily for instrumentation. Some of these additional instrumentation and research projects are likely to include amounts for recombinant DNA research and containment facilities.

Senator KENNEDY. How much do you have now for help and assistance to existing laboratories for this kind of research?

Dr. CLARK. Our program activity in genetics is requesting $9,100,000 for fiscal 1978.

You should understand that in areas like biophysics and biochemistry and also developmental biology, in which the combined funding is about $40 million, that fractions of those programs support recombinant DNA research. Our current funding in the area: We have some 46 projects among several program areas that involve these techniques, and total funding invested so far is about $2.4 million, which is in those projects. That is invested over a 1½-year period.

Senator KENNEDY. Proceed.

Dr. ATKINSON. In the social sciences, we propose to initiate several large data resource efforts, including a major project to analyze data gathered—but not tabulated—in the 1940 and 1950 censuses.

From this analysis, we can gain a more detailed understanding of U.S. population dynamics since 1940 and trends in social indicators such as income distribution.

RESEARCH APPLIED TO NATIONAL NEEDS

For research applied to national needs, we are requesting $78 million, an increase of $10.4 million. Nearly all of this increase is for earthquake engineering and policy studies dealing with the social and economic consequences of earthquakes and earthquake warning systems.

This is a part of a larger Federal effort in earthquake research developed jointly by NSF and the U.S. Geological Survey.

The expanded RANN effort in this area totals $20 million compared with $8.2 million in fiscal year 1977. It gives emphasis to the siting and structural design of buildings—including the reinforcement of existing structures—to minimize damage and casualties from earthquakes.

We also propose to increase support for research on renewable resources such as forest and agricultural wastes. These wastes may serve as nonconventional sources of food protein as well as sources of chemicals and other usable products.

Senator KENNEDY. Some books have been written recently about small-scale technology in communities, to help smaller units to make important contributions in a wide range of different areas of public concern.

I am interested in what RANN does in terms of these smaller technologies? What possibilities exist for NSF to make a contribution in this area?

Dr. ATKINSON. You know the background of the effort, in terms of a little book called "Small Is Beautiful." The general title that now seems to apply, is "Appropriate Technologies." The National Science Foundation, both in the RANN directorate and elsewhere, has been very interested in developments of this sort.

We are sponsoring a major conference on appropriate technologies to be held next year by the American Academy of Arts and Sciences. Many of our projects are oriented toward exploring opportunities in this direction, and the Foundation now has under consideration a number of projects relating to this general effort.

I think it is an area that the Foundation is very well aware of and quite interested in.

Senator KENNEDY. Do you now have or have you in the past, made any grants to any of these groups?

Dr. ATKINSON. Yes; we have. I would be prepared to supply some of that for the record.

Senator KENNEDY. Can you give us a note on this, about what you are doing currently and what the different topic areas are? Perhaps you could give us a little bit about some of those that have been turned down as well. I would be interested in some of the ones that have been turned down and in knowing why.

Dr. ATKINSON. There is going to be a definitional problem here of just what we mean by "appropriate technologies" and how we formulate that note, but we will try to do the best we can.

Senator KENNEDY. Fine.

[The information referred to follows:]

87-769 O - 77 - 3

Senator Kennedy

Question: (Regarding Appropriate Technology):

Can you give us a note on this, about what you are doing currently on it in terms of support; what the different kinds of topic areas are? Perhaps you could give us a little bit about some of those that have been turned down as well. I would be interested in some of the ones that are turned down and the reasons perhaps for that.

Response: The term appropriate technology has come to mean technology that is developed to most effectively use the mix of human and physical resources at the site of application. The concept reflects a growing concern in the society about environmental degradation, resource shortages, unemployment, and increasing urbanization that can be attributed to the use of large-scale production technologies that have been harmful to the environment, wasteful of resources, and capital intensive.

NSF's program of Research Applied to National Needs (RANN) has been supporting several projects over the last few years that are concentrating on issues of waste recycling, substitutes for petrochemicals in agriculture, conversion of waste to feedstuffs, recycling of waste heat, solar energy, and controlled environment agriculture. These projects are closely related to concerns for preservation of the environment, reduction of waste, and wise use of scarce resources that are issues of concern to appropriate technologists. Several but not all of the projects are focused on small-scale application for use by small farmers. A listing of current RANN appropriate technology projects is attached.

In an effort to explore how RANN might further support the application of science and technology to more appropriate solutions to our resource and environmental problems, RANN supported a survey of appropriate technologists in the field, to which more than three hundred groups and individuals responded. We were interested to know about the scope of their activities, the legal and technical problems they face in moving from idea to application, and their recommendations for Federal activity in support of appropriate technology. That report is completed and will be used as a basis for a workshop which will bring together appropriate technologists from the universities and the field to explore how RANN might expand its role of bringing science and technology to bear on appropriate solutions to our resource and environmental problems.

Many of the ongoing appropriate technology projects are being carried out by investigators in research institutions. However, there is a community of appropriate technologists who are field inventors on an individual basis or within small businesses. RANN is currently investigating options for bringing scientific and technical assistance to these inventors in ways that are not a disincentive to their inventiveness.

CURRENT RANN "APPROPRIATE TECHNOLOGY" PROJECTS

Principal Investigator Firm/Institution Award Number	Title	Award Amount	Award Date
C.E.Cook, Jr./E. Eccli Integrative Design Assoc Inc ERS 7621350	Applications of Intermediate or Appropriately Scaled Technologies in the United States-An Exploratory Study	$ 45,500	6/30/76
William J. Oswald Univ of Calif, Bkley AER 7610809 (and A1)	Fertilizer Production with Nitrogen-Fixing Heterocystous Blue-Green Algae	83,700	6/08/76 (+ 8/4/76)
Barry Commoner Washington University AER 7418438A5 (and A4)	Energy Vulnerability of Alternative Systems of Agricultural Production	297,800	9/30/76 (+ 12/17/76)
Jorgensen Univ. of Wisconsin, Mad. AER 7513078A1	Improvement and Evaluation of Processes for Utilization of Protein from Forage for Human and Animal Nutrition	100,000	5/21/76
Otto C. Doering, III Purdue University SIA 7518726	Analysis of Alternative Production Methods and Cropping Systems in the Corn Belt	129,300	8/15/75
Michael L. Shuler Cornell University AER 7605681	Controlled Microbial Conversion of Poultry Waste into a High Protein Feedstuff	74,700	5/19/76
Carlos R. Guerra Public Service Electric and Gas Company ENV 7619854 (and A1)	Utilization of Waste Heat from Power Plants in Aquaculture	469,100	9/30/76 (+ 12/20/76)
Larry Boersma Oregon State University ENV 7414960A2	Utilization of Waste Heat in a System for Management of Animal Residuals to Recover and Recycle Nutrients	41,500	8/04/76

Principal Investigator Firm/Institution Award Number	Title	Award Amount	Award Date
Charles M. Haar Regional and Urban Planning Implementation, Inc. APR 7518360A1	Mortgage Market Constraints on Solar Heating and Cooling	$ 23,000	9/30/76
Roy Hartenstein SUNY-Syracuse ENV 7617225	Utilization of Soil Invertebrates in Stabilization, Decontamination and Detoxification of Residual Sludges from Treatment of Wastewater	88,500	5/28/76
Theodore B. Taylor International Research and Technology Corporation ERS 7512973	Assessment of Controlled Environment Agriculture Technology	309,500	6/19/75
Joan B. Berkowitz Arthur D. Little, Inc. ERS 7302725A1	Technology Assessment of Terrestrial Solar Energy Resources Development	42,919	10/27/75
	TOTAL	$1,705,519	

U.S. ANTARCTIC PROGRAM

Dr. ATKINSON. We are requesting $47.5 million for the U.S. Antarctic program, an increase of $2.2 million. NSF is responsible for all U.S. research conducted in the Antarctic, as well as support activities such as ships, aircraft, helicopters, and the research stations themselves.

The proposed increase includes about $1 million for research and $1.2 million for operations. The increase for operations support is about 3 percent and reflects a determined effort to hold down these costs.

Senator KENNEDY. The Navy used to pay for that, did they not?

Dr. ATKINSON. The Navy provides much of our support, but it is provided through funds from the National Science Foundation.

Senator KENNEDY. How has that changed in recent years? Has there not been more of a shift of that financial burden onto NSF?

Dr. ATKINSON. Dr. Todd, would you describe the situation here?

Dr. TODD. You are correct, Senator Kennedy. There was a major examination of the program a few years ago. In the context of that examination, it was decided that it was appropriate to identify all of the costs associated with the U.S. program in Antarctica and to budget for them through the National Science Foundation budget.

At that time, the Department of Defense went through a careful exercise to identify all of their costs and similarly the Department of Transportation for Coast Guard costs. Those are now in the National Science Foundation budget and I believe this is the second year in which 100 percent of the identifiable costs are in our program.

Senator KENNEDY. So what does that amount to in dollars and cents? What does it mean when you assume those costs, approximately?

Dr. TODD. The NSF budget request is approximately $40 million higher than it otherwise would have been.

Senator KENNEDY. All right.

SCIENCE EDUCATION

Dr. ATKINSON. The Foundation is mandated by Congress to strengthen science education programs at all levels. For this purpose, we are requesting $75.7 million.

We have restructured our science education programs and initiated several new efforts to carry out recommendations of the Congress.

We are proposing an increase of $3.5 million for comprehensive assistance to undergraduate science education, CAUSE, a program designed to help the approximately 2,300 2- and 4-year nonresearch-oriented colleges and universities.

The program would provide 3-year grants of up to $2,500 per grant. The grants go to departments and institutions proposing comprehensive, clearly focused, and long lasting improvements in science education.

For about 750 institutions offering advanced degrees in the sciences, we now support a companion program, research initiation and support, RIAS, designed to meet the training needs of young scientists. There is also a program of small grants to individual faculty members to improve the quality of specific course offerings.

The faculty improvement program now includes the precollege teacher development program established at the direction of the Congress.

These workshops and seminars provide opportunities for both elementary and secondary schoolteachers to strengthen and update their science backgrounds and improve their instructional skills.

The program will provide instruction for approximately 5,000 precollege teachers. We also plan to increase the number of science faculty professional development awards to undergraduate faculty in 2- and 4-year colleges and universities.

The Foundation is also sponsoring a variety of programs to strengthen science education for women, minorities, and the handicapped who are underrepresented among holders of advanced scientific degrees.

The science and society program continues its new Science for Citizens effort, which is just getting started, and has significant potential and usefulness.

Present Science for Citizens activities are experimental and investigatory. It is important, therefore, to take time to learn from the work now in progress.

By the end of this fiscal year, the first round of awards in the public service science residency and internship programs will have been completed and some awards for forums, conferences, and workshops made.

We will also have an opportunity to benefit from studies completed and underway, as well as the deliberations and advice of our Science for Citizens Advisory Committee.

An evaluative statement to the Congress on the program's activities up to October 31, 1977, will have been prepared and delivered. Thus at present we are proposing only a small increase in funds for fiscal year 1978.

SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS

We are requesting $22.6 million for scientific, technological and international affairs, an increase of $2 million over the present year.

This program provides support for international cooperative scientific activities which serve both the needs of U.S. scientists and this Nation's foreign policy objectives. The activity fosters information exchange among scientists, engineers and other users of scientific information.

It also supports the collection and analysis of data needed for science planning and policy formulation by NSF and other Federal agencies. Slightly more than half of the proposed increase of $2 million will support a governmentwide effort to lay plans for the United Nations Conference on Science and Technology for Development to be held in 1979.

In a certain sense, NSF is playing the broker's role for many Federal agencies in planning for this U.N. conference.

PROGRAM DEVELOPMENT AND MANAGEMENT

We are requesting $47.8 million for program development and management, an increase of $2 million for fiscal year 1978.

The request provides for a staffing level of 1,325 positions—including 25 new positions.

It also provides for the increases necessary to maintain about the same level of central support services as in 1977. The costs associated with these support services are, for the most part, not under the control of the Foundation, since they include such items as office rental costs, audit programs and other services provided by government agencies—like CSA—on a reimbursable basis.

The 25 additional positions proposed in the fiscal year 1978 budget are needed to manage the new or expanded NSF programs. Some of these positions are earmarked for more extensive oversight and evaluation of NSF programs and for studies of major policy issues facing American science.

We are proposing $6 million for the special foreign currency appropriation, to be used for the translation of scientific materials and for cooperative research efforts in countries that fall into this category.

Mr. Chairman, in closing, I want to emphasize once again the importance of research to all parts of our society. Whether we are discussing education, health, the management of our economy, or the energy crisis, our ability to cope effectively depends upon a vigorous program of basic research.

Mr. Chairman, this concludes my statement.

We will be happy to answer questions that you or other members of the subcommittee may have for us.

[The NSF fiscal year budget in brief follows:]

National Science Foundation

WASHINGTON, D. C. 20550

BUDGET IN BRIEF

Fiscal Year 1978

TO

THE CONGRESS

ABOUT THE NATIONAL SCIENCE FOUNDATION (NSF)—

NSF is an independent Federal agency.

The Foundation was established as an outgrowth of President Franklin D. Roosevelt's desire for a science agency that could contribute to a peacetime economy and that would enhance U.S. scientific strength. In 1944, President Roosevelt instructed Dr. Vannevar Bush, Director of the Office of Scientific Research and Development, to find a way for the Nation to benefit in peacetime from the wartime experience of Dr. Bush's office and to assure U.S. scientific strength for reasons of national health, prosperity and security.

Dr. Bush's report, *Science, the Endless Frontier*, led to the establishment of the National Science Foundation in 1950 (NSF Act of 1950). NSF's mission was to strengthen U.S. science through support of basic research and science education programs. In 1968, the NSF Act was amended to give the agency additional authority to support applied research on selected national problems.

NSF accomplishes its mission through grants and contracts, primarily with colleges and universities. It has no in-house laboratory facilities. About 2,000 colleges, universities, and other institutions, both public and private, participate in NSF programs. In excess of 30,000 scientists, engineers, and science educators in all parts of the United States review proposals submitted to NSF for support.

NSF, by law, consists of the Director (and staff) and the National Science Board. The National Science Board is the NSF policymaking body and has 25 members, including the Director as an *ex officio* member. The Director and Board members are appointed by the President and confirmed by the Senate for 6-year terms. The term of the Board members are staggered so that the terms of one-third of the members expire every 2 years.

The present Chairman of the National Science Board is Dr. Norman Hackerman, President of Rice University. The Acting NSF Director is Dr. Richard C. Atkinson.

The National Science Board submits annual reports to the Congress through the President on the status and health of science and its various disciplines. The latest reports are *Science at the Bicentennial—A Report from the Research Community* (April 1976) and *Science Indicators—1974* (December 1975).

The Foundation has about 1,300 employees. The Director, Deputy Director, and four Assistant Directors are appointed by the President and confirmed by the Senate. Three Assistant Directors are appointed by the Director. More than 30 percent of the NSF staff are experts in the various fields of science, engineering, and science education. About 4 percent of the staff are "rotators" from academic and other non-governmental institutions who work for the Foundation for 1 or 2 years and then return to their home institutions. They help provide a continuous influx of up-to-date information and fresh viewpoints on the needs and opportunities for research and science education.

National Science Foundation

Washington, D.C. 20550

FY 1978

Budget in Brief

to the
Congress

FY 1978 BUDGET REQUEST . . $885,000,000

- INCREASE OVER FY 1977 LEVEL $87,063,294
- BASIC RESEARCH UP $76.3 MILLION, 12.4 PERCENT, TO $688.1 MILLION
- $108.9 MILLION INCREASE IN NEW OBLIGATIONAL AUTHORITY

NATIONAL SCIENCE FOUNDATION
FY 1978 BUDGET IN BRIEF

CONTENTS

	Page
Budget Summary Tables	3
Overview, Basic Assumptions and Major Goals	5
Program Balance and Questions Driving Research and Science Education	7
Some Details on the NSF Budget and Planning Process	10
FY 1978 Budget Dynamics	12
Cross-cut of Proposed FY 1978 Increases	18
Budget Activity Summaries:	
Budget Summary Table	23
Mathematical and Physical Sciences and Engineering	24
Astronomical, Atmospheric, Earth and Ocean Sciences	25
U.S. Antarctic Program	26
Biological, Behavioral, and Social Sciences	29
Science Education	31
Research Appplied to National Needs	34
Scientific, Technological and International Affairs	37
Program Development and Management	40
Special Foreign Currency Program	42
Recent Management Actions	44

NATIONAL SCIENCE FOUNDATION
Total Dollar Summary

FY 1976 - FY 1978

(Obligations in Millions of Dollars)

Source	FY 1976 Actual	Transition Quarter Actual	FY 1977 Budget Request to Congress	FY 1977 Plan Based on Actual Legislation & Apportionment	FY 1978 Budget Request to Congress	FY 1978 Request-FY 1977 Plan
New Obligational Authority	$715.3	$168.1	$802.0	[1]$776.1	$885.0	$108.9
* Administration Deferrals, Carryover, and Adjustments	9.1	-1.3	10.0	21.8	—0—	-21.8
Total	$724.4	$166.8	$812.0	$797.9	$885.0	$87.1

[1] Includes $2.5 million proposed supplemental appropriation for FY 1977 pay raise costs.

* *FY 1976 Deferrals, Transition Carryovers and Adjustments*—About one-half ($10 million) of the funds carried forward into FY 1977 were Administration deferrals in Science Education. A substantive fraction of the remaining carryover funds results from commitments in process but not completed by September 30, 1976.

NATIONAL SCIENCE FOUNDATION
Budget Summary

(Obligations in Millions of Dollars)

Budget Activity (1)	FY 1976 Actual Obligation (2)	FY 1977: FY 1977 Program Funded by Congress (3)	FY 1977: Current Plan (4)	FY 1978: Total New Obligational Authority (5)	Increases: New Obligational Authority FY 1978-77 (5-3)	Increases: Total Program FY 1978-77 (5-4)
Mathematical and Physical Sciences and Engineering	$192.3	$222.6	$223.9	$249.2	$26.6	$25.3
Astronomical, Atmospheric Earth and Ocean Sciences	171.0	188.7	188.8	213.4	24.7	24.6
U.S. Antarctic Program	48.6	45.3	45.3	47.5	2.2	2.2
Biological, Behavioral and Social Sciences	109.0	126.5	126.6	144.8	18.3	18.2
Science Education	62.5	59.0	74.3	75.7	16.7	1.4
Research Applied to National Needs	72.0	63.9	67.6	78.0	14.1	10.4
Scientific, Technological and International Affairs	22.4	20.0	20.6	22.6	2.6	2.0
Program Development and Management	42.2	45.5	45.8	47.8	2.3	2.0
Subtotal	720.0	771.5	792.9	879.0	107.5	86.1
Special Foreign Currency Appropriation	4.4	4.6	5.0	6.0	1.4	1.0
Total, NSF	$724.4	$776.1	$797.9	$885.0	$108.9	$87.1

[1] Includes $2.5 million proposed supplemental appropriation for FY 1977 pay raise costs.

[2] Includes FY 1976 and Transition Quarter funds carried into FY 1977—$21.8 million (including $10.0 million FY 1976 Administration deferrals).

NATIONAL SCIENCE FOUNDATION FY 1978 BUDGET REQUEST

OVERVIEW, BASIC ASSUMPTIONS, AND MAJOR GOALS

The National Science Foundation's FY 1978 budget request is $885 million, including $879 million for the Salaries and Expenses Appropriation and $6 million for the Special Foreign Currency Appropriation. The program is more than $87 million, or 10.9 percent, above the FY 1977 level. This increase is needed to meet research requirements and opportunities in the science disciplines and engineering and to permit substantial improvements in scientific instruments at academic research laboratories. Additionally, it provides for expanded research on selected national problems, augments efforts to give minorities, women, and other groups underrepresented in science, increased opportunities for careers in science, and increases science education programs.

Areas of program emphasis have been determined on the basis of their potential for strengthening science and for making a significant beneficial contribution to society, particularly over the long term.

Some of the major assumptions and considerations on which the FY 1978 program has been developed are that:

- The Nation will continue its commitment to maintain the U.S. competitive position in science and technology.
- Improvements in environmental quality and the quality of life generally will depend, to a significant degree, upon the ability of science and technology to find economically and socially viable solutions to environmental and related problems.
- A strong scientific capability is essential to the present and future well being of the Nation.
- An expanding base of scientific knowledge is essential to the Nation's economic progress.
- The public expects science to stimulate the development of new and improved technologies, products, and services and that these will lead to the creation of new industries and more and better jobs.
- Domestic needs and international competition will require the United States to take full advantage of the Nation's science and technology capabilities.
- Young people seeking careers in science will be best served by programs that prepare them for several career options in science and related fields.

- Ethical and human value issues related to research, technology, and science education are likely to receive increased attention at both the national and local levels.
- Technology assessment and evaluation of science policy alternatives will be of growing importance as the Nation seeks to employ science and technology increasingly in efforts to resolve a range of societal problems.
- State and local governments can benefit from an improved ability to make effective use of science and technology in the solution of some of their problems.

Major NSF Goals

- Recommend and encourage the pursuit of national policies for the promotion of basic research and education in the sciences. (PL 81-507, Section 3(d))
- Strengthen U.S. scientific research in the mathematical, physical, medical, engineering, biological, social and other sciences. (PL 81-507, Section 3(a)(1))
- Focus an appropriate portion of U.S. science resources on selected current national problems. (Section 3(c))
- Strengthen science education programs at all levels. (Section 3(a)(1))
- Stimulate international scientific cooperation between U.S. and foreign scientists. (Section 3(b))
- Assist in providing the Nation with highly trained scientists and engineers through a program of fellowships for science and engineering. (Section 3(a)(2))
- Foster the interchange of scientific information among scientists in the United States and foreign countries and make science information more readily available to U.S. scientists and engineers. (Section 3(a)(3) and PL 85-864, Sections 901 and 902)
- Appraise the current and projected need for scientific and technical resources in the United States PL 81-507 (Section 3(a)(6))
- Gather and publish scientific and technical data pertinent to national science policy decisionmaking (Section 3(a)(5), (6) and (7))
- Appraise the impact of research on industrial development and upon the general welfare. (Section 3(a)(1))

Program Balance and Questions Driving Research and Science Education

From its inception, the Foundation has sought to maintain U.S. scientific strength through the support of scientific research and science education programs conducted primarily at the Nation's colleges and universities. Research projects carried out in academic research laboratories advance scientific understanding and, at the same time, provide important training opportunities for young people who are seeking careers in science. Consequently, the bulk of NSF support has been and continues to be focused on fundamental research, which offers this dual benefit. At the same time, the Foundation has developed the capacity for identifying important national problems which science and technology can help to resolve. Research directed at selected problems is also a part of the Foundation's support effort.

As of now, there is no "best" formula for determining the appropriate level or mix of Federal support for research, such as a percentage of the total Federal budget, a percentage of the gross national product, or some other such "yardstick". The NSF budget request and the balance among programs are based on a composite of analyses and subjective judgments about science support trends, the condition of the economy, the extent to which science is being called upon to help to resolve certain domestic and international problems, potential breakthroughs in scientific knowledge, the ability of the Nation's universities and colleges and other research organizations to conduct advanced scientific research, and other pertinent factors.

The Foundation's FY 1978 program is the result of continuing program planning efforts that involve all NSF program managers and the National Science Board. The priorities reflected in the budget are based on analyses of a range of inputs, including guidance from the Administration; reports and specific mandates from the Congress; analyses and reports of the National Academy of Sciences, the National Academy of Engineering, professional societies, and NSF sponsored studies; current and projected science manpower needs; and the expertise of NSF advisory groups and consultants, and the National Science Board.

The balance among the Foundation's program activities is also influenced by the importance of various research and science education questions being addressed and the probability that the answers to these questions will provide benefits to the public over the long term. Much of the basic research supported consists of projects which have the potential to significantly increase scientific knowledge, but no clear application to the problems of the Nation. In addition to basic research and science education, a portion of the Foundation's program is devoted to applied research and in these areas questions are targeted on selected problems where new research findings may stimulate the development of improved technologies; provide information needed to help resolve environmental, resource, and productivity problems; or lead to more efficient and effective delivery systems for public services.

Some important questions being addressed in the different fields of science and science education and the implications of the answers to these questions for future advances in science and technology include:

- How can structures be designed and constructed to be both economical and earthquake resistant? In addition to reductions in life loss and personal injury, implementation of improved design procedures is expected to reduce losses to buildings alone by an average of $250 million per year.
- Can simple chemical reactions be discovered that will generate visible radiation? The results of research on this question may lead to inexpensive lasers for communication and industrial uses.
- How does the material pervading the universe collect to form complex organic molecules, stars, and galaxies? Research in this area can provide increased understanding of fundamental natural laws and the origins of the universe.
- What are the physical processes that govern climate? Greater understanding of climate could aid in the prediction of climate changes and allow time for measures to offset their impact.
- To what extent is the stratospheric ozone affected by contamination of long-lived, man-made chemicals? The results of this research are important to man's survival and to the future of major industries.
- What is the petroleum potential of the continental slopes and the adjacent ocean floor beneath deeper waters? This work is helping to identify the resource potential of the ocean's floor.
- How do organisms in the deep sea influence the productivity of the ocean? How will they react to sea floor dumping and mining activities? Answers to these questions will aid in assessing the future of the ocean as an important food source and should also provide baseline data on contamination of the sea.
- To what degree can biological nitrogen fixation be enhanced? Successful research directed toward this question may provide more information on joint plant-bacteria relationships and an environmentally sound method of increasing crop productivity while minimizing energy costs.
- What are the individual and cumulative effects of government regulation on domestic productivity? This research will provide a sound technical basis for assessing the benefits and costs of proposed, as well as existing, government regulations.
- Can new homogeneous catalysts be prepared that will catalyze chemical processes important to the chemical industry? Research in this area could make it possible to make specific molecules needed in industrial processing techniques with minimum energy expenditure and without the creation of unwanted molecules that may pollute the environment.
- What are the limits for communications use of the channel capacity in the visible spectrum? Progress in this area could significantly expand the capacity of optical communication systems, and since these systems use

87-769 O - 77 - 4

glass fibers instead of copper, their use would result in tremendous monetary and resource savings.

- How do cracks initiate and propagate in materials? This research should provide information needed to develop structural materials that resist corrosion and failure under stress.
- How do cells change during growth and development? Advances and understanding in this area should provide insights into the development of cell specialization and, perhaps, the aging process.
- How do enzymes work? This research should help discover how enzymes selectively catalyze and control the chemical reactions carried out by living systems. The results of this research should extend knowledge on how to synthesize molecules in living cells.
- What are the molecular mechanisms by which genes are regulated to produce specialized products, and what new information is required to exploit the new DNA recombinant technology? This work may lead to improved knowledge of gene action.
- What are the factors controlling cognitive development? For example, how can the large number of component processes involved in reading and understanding a paragraph be characterized? Research on this question should provide new knowledge on the processes involved in reading and comprehending text. Such work is important in providing a basis for improving the techniques for teaching people to read and comprehend.
- What are the mechanisms responsible for sensory signal processing, neural membrane phenomena, and distinct chemical operations of nerve junctions? Research in these areas will extend knowledge of perception, behavior, and the chemical functioning of the nervous system.
- What constitutes student success in science and how can it be measured? What personal characteristics contribute to individual achievement in science? The results of these efforts should help identify the effects of school science programs, teachers, and nonschool programs on student achievement.
- What are the relationships between the teaching strategies employed and student motivation or student comprehension and retention of scientific information and procedures? This work will provide new insights on the relationship of classroom teaching techniques and processes to student learning and performance.
- What important questions in science education remain unanswered? Work in this area will provide a mechanism for addressing current science education issues by conducting a critical analysis of the existing body of scientific and educational research results.

The Foundation's resources are concentrated in three general support categories—Research; Science Education; and Science Related Activities. A fourth category, Program Development and Management, covers the Foundation's operating costs including staff salaries, supplies, etc. The relative balance among the categories as a percentage of the total NSF program for FY 1978 is as follows:

Research ($688.1 million basic, $78.1 million applied; $47.2 million R&D facilities)	83.5 percent
Science Education	8.6 percent
Science Information, Science Policy, International Science Related Activities	2.5 percent
Staff Salaries and Other Operating Costs (Program Development & Management)	5.4 percent
	100.0 percent

Some Details on the NSF Budget and Planning Process

More than 400 NSF program managers and top NSF research administrators who are experts in their fields develop the program plans on which the budget is based. The program managers assess the needs and opportunities in their areas of responsibility. Their assessments and recommendations are based upon information from professional societies, from the National Academies of Science and Engineering, from contacts with thousands of scientists in all parts of the country, and from members of NSF program panels and from thousands of ad hoc reviewers. They also obtain information on Federal science support programs from their counterparts in other agencies, especially the National Institutes of Health, the Department of Defense, the National Aeronautics and Space Administration, and the Department of Agriculture.

A major role in the budget process is performed by the National Science Board, the policymaking body of NSF, which consists of 25 Presidential appointees, including the Director of NSF. The Board makes assessments of science needs and opportunities and suggests areas for program emphasis, constraint, reduction, and reorientation. This information is given to NSF program managers who incorporate the suggestions into the proposed programs.

The recommendations and guidance of Congressional oversight committees mandating certain NSF program directions and emphases are taken into account as are recommendations of the President's Science Advisor and the President himself.

The Foundation's program is correlated with the programs of other Federal research support agencies through various interagency coordinating committees, frequent interaction among agency program managers and research administrators, and through Federal-wide efforts of the Office of Management and Budget. The heads of other Federal agencies and bureaus that support research also briefed NSF on their science support plans and budget proposals for FY 1978 and this information was considered in finalizing NSF program plans and budget estimates.

Using the inputs from these various sources, the Foundation's staff developed definitive program plans and budget estimates for FY 1978. These plans were developed at three levels:

- An Opportunity Level;
- A Planning Level; and
- A Fallback Level.

The Opportunity Level was designed to identify priority research needs and assess areas where research could exploit unusual opportunities for science advancement. The Planning Level provided for minimum growth and for a limited response to recognized opportunities. The Fallback Level represented a no-growth plan. This three-level strategy permits NSF to identify science priorities, alternatives, and program issues.

The proposed program plans and budget estimates at each of the three levels were presented to the NSF Director by the Assistant Directors. He reviewed the plans and made recommendations for changes in program emphasis, for initiatives, and reductions. The plans along with the Director's initial views, were then presented to the National Science Board's Committee on Budget. The Committee held 2 days of internal hearings on FY 1978 program proposals. These hearings concentrated on issues and on the dynamics of the budget—the alternatives and priorities at different budget levels. Then, The Committee reported to the NSF its views and recommendations on issues, program plans, and directions. At this point, the NSB approved the plan at the planning level and made recommendations for incorporating, items in the opportunity level as part of the NSF budget proposal to the Administration. The Foundation's Director makes the final decisions on the agency program that is presented to the Executive Office of the President. The Assistant Directors and other top management program personnel are involved in the entire budget and planning process and assist the Director in arriving at an appropriate program balance. In September 1976, the agency's program plans and budget estimates were formally submitted to the Executive Office of the President for review. The program was fitted into the total Federal R&D support package that is now included in the President's budget for FY 1978.

The National Science Foundation is a major factor in the support of basic research at the nation's academic institutions. In FY 1978, NSF will account for more than 46 percent of Federal funds provided to these institutions for basic research in nondefense/nonspace areas. This compares with an NSF share of about 42 percent in FY 1975.

FY 1978 BUDGET DYNAMICS

The Foundation's research, science education, science information, and related activities, and staff and other agency operating costs are budgeted in nine separate activities as summarized in the following table:

Budget Activity Comparison FY 1978/FY 1977
(Millions of Dollars)

Program Activity	FY 1977		FY 1978		Increase (FY 1978-77)	
	Amount	Percent of Total	Amount	Percent of Total	Amount	Percent Increase
Mathematical & Physical Sciences and Engineering	$223.9	28.1	$249.2	28.2	$25.3	11.3
Astronomical, Atmospheric, Earth & Ocean Sciences	188.8	23.6	213.4	24.1	24.6	13.0
U.S. Antarctic Program	45.3	5.7	47.5	5.4	2.2	4.9
Biological, Behavioral and Social Sciences	126.6	15.9	144.8	16.4	18.2	14.4
Science Education	74.3	9.3	75.7	8.5	1.4	1.9
Research Applied to National Needs	67.6	8.5	78.0	8.8	10.4	15.4
Scientific, Technological, and International Affairs	20.6	2.6	22.6	2.5	2.0	9.7
Program Development and Management	45.8	5.7	47.8	5.4	2.0	4.4
Subtotal	$792.9	99.4	$879.0	99.3	$86.1	10.9
Special Foreign Currency Appropriation	5.0	0.6	6.0	0.7	1.0	20.0
Total, NSF	[1]$797.9	100.0	[1]$885.0	100.0	$87.1	10.9

[1] Included in the above activities is $3 million for research support under the U.S./U.S.S.R. Cooperative Research Agreement as follows: MPE, $2.106 million; BBS, $0.45 million; STIA, $0.444 million; and RANN, $0.1 million.

The proposed FY 1978 program strengthens basic research in all major fields of science. Basic research increases from $612 million in FY 1977 to $688 million in FY 1978 or by 12.4 percent. This permits about a 6 percent growth in the level of effort year to year. Applied research increases from $59.8 million to $72.4 million reflecting a major thrust in earthquake engineering. About $60 million of the $688.1 million is earmarked for instrumentation, facilities, and research resources—about $28 million more than the FY 1977 level for these items. More than 30 percent of the proposed increase of $87.06 million for FY 1978 is earmarked for scientific instruments and facilities. Additionally the program gives emphasis to research on selected problems of national concern including earthquake research and efforts that are closely coupled to improvements in technology, environmental quality, and economic productivity. The program continues research in the polar regions and at five major research centers sponsored by the NSF; it strengthens major international cooperative research efforts in chemistry, oceanography, biology, and the atmospheric and earth sciences; it provides for science policy research and analysis; and it strengthens science education and science information activities.

The dynamics of the nine budget activities are:

Mathematical and Physical Sciences and Engineering—($249.2 million)

- Continues strong support for high quality research projects in mathematics, computer research, physics, chemistry, engineering, and materials research.
- Substantially increases support to obtain instrumentation and equipment needed for advanced research in the physical sciences and engineering.
- Increases support for new and ongoing research on catalysis, laser chemistry and reaction mechanisms and engineering.
- Provides partial support along with the Energy Research and Development Administration (ERDA), for a National Resource for Computation in Chemistry (NRCC). This facility begins operation in FY 1977. It provides a unique and powerful computational resource designed to solve major high priority research problems in chemistry and related sciences.
- Initiates a major synchrotron radiation program (closely coordinated with ERDA) to upgrade and expand synchrotron facilities at Stanford University and the University of Wisconsin and to develop a new synchrotron radiation facility.
- Continues support for advanced research in mathematics with increased emphasis on research in finite groups, nonlinear wave phenomena, functional analysis, and the application of algebraic methods to operator theory.
- Makes a start on the conversion of the Cornell synchrotron to a colliding beam facility for advanced research in physics.
- Provides for increased utilization of the Nation's existing accelerators.
- Increases support for work on intelligent systems and experimental instrumentation for computer science.
- Provides $2.3 million, the same level as in FY 1977, for the support of cooperative research in several science areas conducted under the U.S./U.S.S.R. Science and Technology Agreement.

Astronomical, Atmospheric, Earth, and Ocean Sciences—($213.4 million)

- Continues on schedule the construction of the Very Large Array for Radio Astronomy.
- Provides most of the support for the Sacramento Peak Observatory.
- Increases support for atmospheric research, especially atmospheric chemistry related to the ozone depletion problem.

- Provides the additional funds needed for the first full year's rental of the new 5th-generation computer at the National Center for Atmospheric Research.
- Provides for continuation of the International Phase of Ocean Drilling of the Ocean Sediment Coring Program using the deep sea drilling ship *Glomar Challenger*.
- Increases research aimed at an improved understanding of geologic phenomena giving rise to earthquakes.
- Increases support for ocean research projects related to natural resources and weather and climate.
- Continues support of the academic fleet.
- Increases arctic research related to resources and environment.

U.S. Antarctic Program—($47.5 million)

- Increases mineral and marine resources and environmental research.
- Continues the operations support required for the U.S. Antarctic Research program and provides a continued U.S. presence in Antarctica.

Biological, Behavioral, and Social Sciences—($144.8 million)

- Provides new instrumentation needed for advanced work on subcellular organelles, enzyme catalytic mechanisms, gene expression, cell division, and physiological processes in tissues.
- Provides containment facilities for bio-hazardous research.
- Increases research on photosynthesis, nitrogen fixation, and plants for possible application to food production and reducing dependance on chemical fertilizers.
- Restores anthropological research collections and uses the newest techniques for dating archeological finds.
- Augments research on the nervous system and sensory systems aimed at discovering the determinants of behavior.
- Continues strong support of research in ecosystem studies that may provide insight on improved land and resource management strategies.
- Provides field research facilities essential for environmental biology.
- Expands research on theoretical and empirical foundations for economic stabilization measures which relate to problems of employment, production, and inflation.

Science Education ($75.7 million)

- Increases support for programs which provide for improvement of quality science instruction and research training at 2-year, 4-year colleges and the undergraduate components of universities. These efforts are concentrated on: Comprehensive Assistance to Undergraduate Science Education (CAUSE) program, and the Undergraduate Instructional Improvement program.

- Augments support aimed at providing greater opportunities for minorities, women and the handicapped to pursue careers in science and engineering, including plans for establishing regional Minority Centers for Graduate Education.
- Provides for research to identify and solve educational problems in science and engineering.
- Expands support for activities that encourage and facilitate interaction between citizens and scientists on public policy and ethical issues relating to science and technology.
- Decreases support for program activities that could result in an increased flow of scientific personnel into the Nation's job market so as not to aggravate a potential oversupply problem.
- Decreases support for curriculum development.
- Establishes new program directions through the coordination or merging of new or existing program structures. Specific examples are: (1) Transfers the Science Faculty Resources program element from Resources Improvement to Manpower Improvement and combines it with the new Pre-College Teacher Development program to form the Faculty Improvement program; (2) combines the Instructional Scientific Equipment program with the Local Course Improvement program to form the Undergraduate Instructional Improvement program.

Research Applied to National Needs—($78.0 million)

- More than doubles the research effort in earthquake engineering.
- Continues strong support for research on renewable resources with emphasis on biomass utilization and nonconventional sources of food.
- Decreases support for weather modification by about 40 percent as result of completion of field phase of National Hail Research Experiment.
- Accelerates research on post disaster audits and national disaster warning systems.
- Decreases slightly the research effort on productivity in public and private sectors. Some funds shifted to systems analyses aimed at identifying where research may be applied to improve processes used to convert raw materials into finished products.
- Provides for evaluation of State Science, Engineering, and Technology experimental program being conducted in FY 1977. Funds freed up by completion of experiment shifted to Earthquake Engineering.

- Continues 10 percent small business minimum mandated by Congress in previous years.
- Provides for increased exploratory research on problems of closed-cycle economy.

Scientific, Technological and International Affairs—($22.6 Million)

- Continues strong support for international cooperative scientific activities through bilateral and multilateral research and exchange programs.
- Initiates planning for U.S. participation in the United Nations Conference on Science, Technology, and Development planned for 1979 or 1980.
- Provides new bilateral science and technology cooperative research under agreements being negotiated by the State Department.
- Increases support for U.S. participation in the International Institute of Applied Systems Analysis, and other international scientific organizations.
- Maintains a balanced program of science information activities designed to understand the role of scientific and technical information in the R&D process and to improve access to such information.
- Provides for science and technology policy research and assessment for existing and emerging national issues.
- Supports the collection and analysis of data on the funding of research and development and on scientific and engineering manpower in the United States.
- Updates studies of R&D activities of State government agencies and of the role and education of postdoctorates; initiates study of the R&D activities of nonmanufacturing firms; and extends the development of Science Indicators.
- Continues the planning, evaluation, and analysis of Foundation programs and mission activities.

Program Development and Management—($47.8 million)

- Provides funding for an increase of 25 positions.
- Permits maximum utilization of existing positions.
- Maintains current level of travel and increased travel costs due to higher fares and per diem rates.
- Funds increased costs of Central Support Services.

Special Foreign Currency—($6.0 million)

- Expands joint research efforts with Egypt in conjunction with the Joint Commission for Economic Cooperation and with India and Pakistan.

- Continues translations of the technical literature from approximately 20 languages for US Government agencies, as well as the U.S. scientific community at large.

CROSS-CUT OF FY 1978 INCREASES BY ACTIVITIES AND SUPPORT CATEGORIES

(Dollars in Millions)

	Research								
	Fundamental Laws, Processes and Phenomena	Instrumentation Equipment, Facilities and Research Resources	Environment and Resources	Technology Related Research	Subtotal Research	Science Education	Science Policy Informatn Internl & Related Activities	Staff Salaries and Other Operating Costs	Total Increase
Mathematical and Physical Sciences and Engineering	$5.48	$17.28	....	$2.55	$25.31	....	....	....	$25.31
Astronomical, Atmospheric, Earth, and Ocean Sciences	3.60	4.50	$16.50	....	24.60	....	....	....	24.60
U.S. Antarctic Program	....	....	2.15	....	2.15	....	....	....	2.15
Biological, Behavioral and Social Sciences	10.35	6.20	1.60	....	18.15	....	....	....	18.15
Science Education	....	....	....	....	....	1.40	....	....	1.40
Research Applied to National Needs	....	....	10.40	....	10.40	....	....	....	10.40
Scientific, Technological, and International Affairs	....	....	....	....	....	....	2.00	....	2.00
Program Development and Management	....	....	....	....	....	....	....	2.04	2.04
Special Foreign Currency	1.01	....	....	....	1.01	....	....	....	1.01
Total Increase	$20.44	$27.98	$30.65	$2.55	$81.62	$1.40	$2.00	$2.04	$87.06
Percent of Total Increase	23.5%	32.2%	35.2%	2.9%	93.8%	1.6%	2.3%	2.3%	100.0%

A CROSS CUT OF THE PROPOSED FY 1978 INCREASES

The FY 1978 budget request provides for an enhanced research capability across the entire spectrum of the sciences and for the pursuit of selected applications of this science to important national problems. It will help to maintain and develop research resources, advanced scientific instrumentation, complex data sets and analyses, innovative techniques for gaining greater scientific knowledge and significant new technologies, all of which are of importance to the continued well-being of the Nation.

Research projects supported by NSF are selected on the basis of scientific merit and potential contribution to the body of scientific knowledge and understanding. Results of research may be useable by the same or by other areas of science, or they may require applied research and then development in order to have a social or economic benefit. In some cases, the results may have to be combined with other research findings before they can be applied and their value realized. Obtaining the full economic value from research ultimately depends on the willingness and ability of the private sector to provide the capital needed to finance the conversion of knowledge into specific products and services.

Research supported by NSF is interrelated and multi-applicational. That is, the results of research in one area benefit others. A chemistry research project, for example, might benefit work on environmental problems, industrial processing techniques, or may provide new knowledge on how to make safe use of sewage sludge. Similarly, research in the mathematical and physical sciences and engineering has a great deal of unity and cohesiveness. The intertie among all the sciences, including the biological, social and environmental sciences, has become increasingly apparent in recent years with the emergence of such areas of study as bio-engineering and the recognition that the social sciences must be employed to provide a complete understanding of problem areas and to insure that the results of research are put to good use.

The following section provides a primary cross-cut of the Foundation's proposed increases for FY 1978 showing research and science education emphases. It is important to recognize that the thrusts in these areas will benefit other areas as well. These are grouped here by what is considered their primary motivation.

EMPHASIS ON RESEARCH ($81.62 million increase)

Nearly 94 percent, or $81.62 million, of the total increase of $87.06 million, is earmarked for various research emphases. The increase provides for about a real 6 percent growth in the level of effort in this area after taking inflation into account.

Fundamental Laws, Processes, and Phenomena ($20.44 million increase)

More than $20 million or about 25 percent of the $81.62 million increase for research is on fundamental laws, processes, and phenomena. The Foundation is increasing research support in astronomy, physics, mathematics, chemistry, the biological, behavioral and social sciences, and portions of environment related research in the earth, ocean and atmospheric sciences. The increased research support would be used to expand efforts in such areas as the mathematics of nonlinear wave propagation, nuclear research synthesis and reaction mechanisms, catalysis, and research on the structure and functions of subcellular organelles, enzyme catalytic mechanisms, cell division and physiological processes in tissues.

Instrumentation, Facilities and Research Resources—($27.98 million increase)

More than 34 percent or $27.98 million of the $81.62 million increase proposed for research activities would be used to upgrade instrumentation, equipment and facilities in such fields as chemistry, physics, biology, materials, and engineering, and in the astronomical, atmospheric, earth, and ocean sciences. This increase together with the amount in the base program for this purpose brings the total amount in the NSF budget for instrumentation and facilities to more than $60 million including the continued construction of the Very Large Array.

The proposed increase permits more effective utilization and upgrading of major research facilities primarily in the fields of physics and materials science and will also provide for upgrading the capability of the NCAR computer and for continued support for construction of the Very Large Array astronomy facility. A major item in this area is the provision of enhanced capabilities for the utilization of synchrotron radiation through the upgrading and expansion of present facilities and the development of a new source. This new synchrotron radiation source is needed to satisfy the research needs of the scientific community outside elementary particle physics. Among these increases are:

$3.2 million for initial support for the conversion of the Cornell University synchrotron to a colliding beam facility.

About $0.8 million of the increase is for design studies of a heavy ion accelerator.

$1.0 million will support improved data resources for the social sciences including the conversion of census and current population survey data into machine readable form for further research and expansion of the data base for long range comparative studies.

$.4 million will improve the capability of field research sites used by biological scientists.

$.8 million will provide containment facilities for research involving recombinant DNA.

$1.2 million for a new high frequency ionospheric heating facility at the National Astronomy and Ionosphere Center.

Environment and Resources—($30.65 million increase)

More than $30 million of the increase is for research in the general area of the environment and resources. The increases and major areas of emphasis include:

- $5.8 million for earth sciences research aimed at gaining new knowledge that can lead to better techniques for earthquake prediction, and can benefit the exploration for petroleum and mineral resources.
- $9.6 million to accelerate research on earthquake engineering, on disaster post-audits, and on methods for reducing economic losses from acid rain.
- $0.8 million to initiate a proof-of-concept experiment on safe methods of disposing of municipal sludge, to begin research on methods of incorporating environmental quality considerations into architectural and urban design practice, and to expand research on chemical threats to man and the environment.
- $0.7 million to permit acceleration of fundamental research and research on innovative methods for converting agricultural and forest wastes (biomass) to chemicals and other usable products. Specifically, the increase planned for FY 1978 will support studies on organisms that degrade lignin and cellulose.
- $10.4 million for studies of the atmosphere and the oceans, related to both weather and climate and to the impact of pollutants, and research on living and mineral resources in the marine environment.
- Research on plants, biological fixation of nitrogen, photosynthetic efficiency, and nonconventional sources of food. This research is aimed at enhancing the Nation's ability to produce food, while, at the same time, minimizing dependence upon chemical fertilizers. Also included is fundamental research on natural and man-modified ecosystems including research on the biological control of insect pest populations.

Technology Related Research—($2.55 million increase)

Approximately $2.6 million of the proposed increase will be devoted to basic and applied research studies on chemical processing techniques and various aspects of materials science and engineering directly relevant to advances in technology.

EMPHASIS ON SCIENCE EDUCATION ($1.40 million increase)

The FY 1978 program increases by $1.4 million over the FY 1977 total of $74.3 million. The program changes include:

- Decreases of $3.05 million in Science Education Development and $660,000 in Manpower Improvement.
- Increases of $4.23 million in Science Education Resources Improvement and $880,000 in Science and Society.

Most of the increase has been designated for the following science education thrusts in FY 1978:

- $3.5 million to improve the quality of undergraduate science instruction and research training in colleges and universities including 2-year colleges.
- $0.88 million for strengthening efforts to meet an increasing public demand for greater participation in, as well as understanding of, public policies in science and technology and the corresponding social and ethical implications.
- $0.3 million to augment ongoing programs aimed at improving the quality of graduate science training for minority students.

EMPHASIS ON SCIENCE POLICY, SCIENCE INFORMATION, INTERNATIONAL, AND RELATED ACTIVITIES—($2.00 million increase)

Support for work in these areas will increase by approximately $2.0 million or 8 percent above the FY 1977 total of $24.6 million. These expanded efforts include:

- $1.8 million for the International Cooperative Science program for U.S. preparations for the U.N. Conference on Science and Technology, planned for 1979 ($1,100,000); new initiatives in scientific cooperative programs with East European countries, the Peoples' Republic of China, Latin America, and East Asia ($300,000); and increased dues and administrative costs for international scientific organizations, primarily the International Institute of Applied Systems Analysis in Vienna ($400,000).
- $200,000 for the Science Assessment, Planning and Policy program in support of Science Resources Studies to improve analyses of U.S. science and technology and to continue and upgrade the periodic surveys needed to maintain the national R&D data base.
- Expanded cooperative research efforts with Egypt, India and Pakistan funded with special foreign currency.

PROGRAM DEVELOPMENT AND MANAGEMENT—($2.00 million increase)

- Includes $489,000 initial funding of 25 new positions.
- An additional $600,000 for maximum utilization of existing permanent positions.
- $200,000 to maintain the current level of travel and offset fare and per diem increases.
- Increases in telephone rates and postage requires an additional $180,000
- Miscellaneous contract services and equipment purchases requires $310,-000

NATIONAL SCIENCE FOUNDATION
Budget Summary by Activity

	Actual FY 1976	Actual Transition Quarter	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978-77	Percent Change FY 1978/77
Mathematical & Physical Sciences and Engineering	$192,265,047	$44,982,150	$233,250,000	$223,889,718	$249,200,000	$25,310,282	11.3%
Astronomical, Atmospheric, Earth, and Ocean Sciences	170,986,146	39,924,360	199,700,000	188,800,000	213,400,000	24,600,000	13.0%
U.S. Antarctic Program	48,585,292	13,435,129	45,000,000	45,325,000	47,475,000	2,150,000	4.9%
Biological, Behavioral & Social Sciences	109,035,414	29,727,850	132,650,000	126,650,000	144,800,000	18,150,000	14.4%
Science Education	62,480,680	3,656,997	65,000,000	74,300,000	75,700,000	1,400,000	1.9%
Research Applied to National Needs	72,026,697	17,420,246	64,900,000	67,600,000	78,000,000	10,400,000	15.4%
Scientific, Technological, and International Affairs	22,410,183	6,148,482	22,000,000	20,600,000	22,600,000	2,000,000	9.7%
Program Development and Management	42,226,021	10,518,124	43,500,000	45,788,291	47,825,000	2,036,709	4.4%
Subtotal	720,015,480	165,813,338	806,000,000	792,953,009	879,000,000	86,046,991	10.9%
Special Foreign Currency Appropriation	4,402,046	1,010,508	6,000,000	4,983,697	6,000,000	1,016,303	20.0%
Total, NSF	$724,417,526	$166,823,846	$812,000,000	$797,936,706	$885,000,000	$87,063,294	10.9%

PROGRAM ACTIVITY SUMMARIES

MATHEMATICAL AND PHYSICAL SCIENCES AND ENGINEERING

FY 1978 Program Total $249,200,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
Mathematical Sciences	$17,256,900	$20,900,000	$19,900,000	$21,800,000	$1,900,000
Computer Research	13,215,579	15,800,000	15,500,000	17,000,000	1,500,000
Physics	45,171,408	55,450,000	54,139,718	59,400,000	5,260,282
Chemistry	34,650,083	42,350,000	40,200,000	44,300,000	4,100,000
Engineering	35,848,250	44,650,000	42,600,000	46,100,000	3,500,000
Materials Research	46,122,827	54,100,000	51,550,000	60,600,000	9,050,000
Total	$192,265,047	$233,250,000	$223,889,718	$249,200,000	$25,310,282

Program Activity Goals and Description

The goal of the Mathematical and Physical Sciences and Engineering (MPE) Activity is to promote the progress of science in mathematics, computer research, physics, chemistry, engineering, and materials research through:

- support of the highest quality research projects and scientific instrumentation so that the Nation can continue and strengthen its leadership in these fields.

New knowledge in the fields covered by MPE has both intrinsic interest and the potential for wide applicability to problems in the "real world."

Explanation of FY 1978 Increases and Decreases

The requested increase of $25.3 million in the MPE Activity is 11.3 percent above the FY 1977 current plan of $223.9 million. Within the total of $249.2 million requested for FY 1978, all subactivities will receive additional funds which will be greater than the increase necessary to merely offset the increased cost of doing research. In Chemistry, increased research emphasis is expected in catalysis, laser chemistry, chemical computations, synthesis, and reaction mechanisms. In Engineering, a special effort will be made to increase the availability of modern research instrumentation at Engineering schools. In Mathematics, increased emphasis will be placed on research in finite groups, nonlinear wave phenomena,

87-769 O - 77 - 5

functional analysis, and the application of algebraic methods to operator theory, statistical inference, and estimation, among others. Computer Research will receive an increase that allows for increased work on intelligent systems and expanded instrumentation for computer science. Much of the requested increase in Physics will go to increase the utilization of existing accelerators and to allow NSF to assume support of some Energy Research and Development Administration (ERDA) dropouts in nuclear physics. The Materials Research subactivity, which increases by 17.6 percent over the FY 1977 estimate, will take lead responsibility for providing increased facilities for synchrotron radiation required for research on a variety of problems involving materials science, chemistry, and biology.

ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES ACTIVITY

FY 1978 Program Total $213,400,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
Astronomical Sciences	$48,634,694	$54,675,000	$52,300,000	$58,000,000	$5,700,000
Atmospheric Sciences	44,527,599	51,375,000	49,550,000	55,900,000	6,350,000
Earth Sciences	27,120,680	32,175,000	29,000,000	34,800,000	5,800,000
Ocean Sciences	47,081,625	56,475,000	53,250,000	58,900,000	5,650,000
Arctic Research Program	3,621,548	5,000,000	4,700,000	5,800,000	1,100,000
Total	$170,986,146	$199,700,000	$188,800,000	$213,400,000	$24,600,000

Program Activity Goals and Description

The Astronomical, Atmospheric, Earth, and Ocean Sciences Activity supports basic research in selected disciplines that will increase our knowledge of the physical environment on earth and in space. The overall objectives of the various elements comprising the Activity are as follows:

- Obtain new knowledge in astronomy and the atmospheric sciences over the entire spectrum of physical phenomena;
- Provide a better understanding of the physical and chemical make-up of the earth and its geological history;
- Obtain further insights into the composition, structure, behavior, and resources of the oceans, and examine the effect of human activities on the ocean environment and vice versa;
- Advance knowledge of natural phenomena and processes in the Arctic.

The discipline orientation of the elements of this Activity facilitates overview and assessment of the "health" of these scientific disciplines and permits the exercise of critical judgment in the allocation of resources among elements within the disciplines.

In making such judgments, appropriate use is made of available input from outside sources, including advisory bodies and information on the state of the discipline in general.

The objectives are pursued through the following subactivities:

Astronomical Sciences: Support of basic research projects and national research facilities is directed at examining the physical principles governing the universe including the structure of the planets and their atmospheres, the solar system, the Milky Way, and remote galaxies.

Atmospheric Sciences: Support is provided for basic research projects and for the National Center for Atmospheric Research, to facilitate our understanding of the behavior of the earth's atmosphere.

Earth Sciences: The programs under Earth Sciences are designed to increase our basic knowledge of the solid earth, including its ocean floor. This is pursued through Earth Science Project Support and the Ocean Sediment Coring Program.

Ocean Sciences: The activities supported are geared to improving Man's understanding of the nature of the ocean, and its influence on Man's activities and of Man's impact on the marine environment. This is accomplished through Oceanography Project Support, the International Decade of Ocean Exploration, and support for oceanographic facilities essential to the research efforts.

Arctic Research Program: Research is pursued in two categories: Environmental and Resource-Related. Among the studies underway are those on the dynamics of sea ice, deep ice core drilling in Greenland, the arctic tundra, and the resources of the Bering Sea Shelf.

Explanation of FY 1978 Increases and Decreases

The total estimated program for FY 1978 is $213,400,000, or $24,600,000 above the Current Plan for FY 1977 of $188,800,000.

An increase of $5,700,000 in Astronomical Sciences will provide for increased research, improvements in instrumentation, radio spectrum studies, procurement of waveguide for the Very Large Array (VLA), a new ionospheric heating facility at the National Astronomy and Ionosphere Center, and small increases for several of the National Research Centers to cover increased instrumentation and rising administrative costs.

The $6,350,000 increase in Atmospheric Sciences will be used for: expansion of research in atmospheric chemistry; continued support of the International Magnetospheric Study; acceleration of planning and research for the Monsoon Experiment and research under the Climate Dynamics Program. For the National

Center for Atmospheric Research, increased funding will be used for the first full-year rental of the fifth generation computer and acquisition of peripherals, increased balloon flights, improved instrumentation, long duration balloon testing, and rising administrative and research costs.

Earth Sciences requires an increase of $5,800,000, of which $5,300,000 will be used for project support and $500,000 for the Ocean Sediment Coring Program (OSCP). Increased emphases will be on studies of earthquake mechanisms and of possible earthquake precursors. The estimated funding for OSCP is needed to cover increased costs for operating *Glomar Challenger*, such as fuel, drilling subcontract, geophysical site surveys, and new drill pipe.

An increase of $5,650,000 for Ocean Sciences will provide for: the use of newly developed research tools for studies in physical oceanography and marine chemistry, plus expanded studies of the rock samples obtained through the Deep Sea Drilling Project; major field efforts such as the North Pacific Experiment (NORPAX), the POLYMODE project, and the final Indian Ocean field program of the Geochemical Ocean Sections Study (GEOSECS); increased studies of processes in the coastal zone and on the continental shelf; and for additional ship and submersible time for the previously mentioned field work plus rehabilitation and upgrading of instrumentation and of older ships in the oceanographic fleet.

The $1,100,000 increase in the Arctic Research Program will provide support for increased research in studies of air-sea-ice interaction and the mechanical properties of ice; ecological research on high arctic mammals; research on regional ecosystems and permafrost; and the second year of the Bering Sea ecosystems study.

U.S. ANTARCTIC PROGRAM

FY 1978 Program Total $47,475,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
U.S. Antarctic Research Program	$4,308,496	$5,100,000	$5,550,000	$6,475,000[1]	$925,000
Operations Support Program	26,276,796	39,900,000	39,775,000	41,000,000[2]	1,225,000
LC-130 Aircraft Procurement	18,000,000[3]	—0—	—0—	—0—	—0—
Total	$48,585,292	$45,000,000	$45,325,000	$47,475,000	$2,150,000

[1]These funds will support scientific activities in Antarctica during the September 1978 to March 1979 austral summer field season.

[2]These funds will provide support for the research activities to be conducted in Antarctica during the October 1977 to March 1978 austral summer field season.

[3]For two LC-130R aircraft for which funds were appropriated by Public Law 94-116.

Program Activity Goals and Description

Within the context of the Antarctic Treaty, the U.S. Antarctic Program supports national goals to: maintain the Treaty to insure that the continent will continue to be used for peaceful purposes only, foster cooperative research to contribute to the solution of regional and worldwide problems, protect the environment, and insure equitable and wise use of living and nonliving resources.

The United States has a reputation for leadership in antarctic affairs and has extensive rights, based on exploration, discovery and presence in that area.

The antarctic area is of further interest to the United States because it:

- has a major influence on world weather and climate,
- contains potentially valuable minerals and petroleum,
- is the world's richest area in marine protein production,
- has other features of unique scientific and practical interest, and
- provides an excellent environment for international cooperation through the Antarctic Treaty.

The National Science Foundation has been assigned overall management responsibility for planning, funding, and implementing the national program in Antarctica. The Foundation's responsibilities for the overall program in Antarctica are in accordance with Office of Management and Budget Circular A-51 (revised).

The U.S. Antarctic Research Program subactivity supports a multidisciplinary research program on the Antarctic continent and in the adjacent oceans. The research is focused to increase scientific knowledge through environmental and resource-related programs. The research is conducted at four antarctic stations, from remote temporary field sites, and aboard two research ships. Remote sensing techniques, using satellites, aircraft, rockets, balloons, and unmanned stations, are utilized in the conduct of the research. Cooperative research programs with scientists of other nations are commonplace.

The Operations Support Program subactivity provides for the direct support of science activities and the maintenance of an effective U.S. presence in Antarctica.

The National Science Foundation is designated as the single source of funding and management for the U.S. Antarctic Program. The Department of Defense and the Department of Transportation provide operational support on a cost reimbursable basis. The Foundation also contracts for support services when it is cost effective.

Explanation of FY 1978 Increases and Decreases

Support for this activity totals \$47,475,000 in FY 1978, an increase of \$2,150,000, or 4.7 percent over FY 1977. This is the former U.S. Antarctic Research Program, which is now budgeted as a separate activity.

The Research subactivity increases by \$925,000, or 17 percent, to \$6,475,000, with emphasis being placed on the environmental portion of the research, although resources research is also increased.

The Operations Support subactivity increases by \$1,225,000, or 3 percent, to \$41,000,000. The increase is primarily for the direct support of research. The other major program element—support required to provide a continued U.S. presence in Antarctica—increases by only about 1 percent, to \$34,130,000.

BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES

FY 1978 PROGRAM TOTAL $144,800,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
Physiology, Cellular & Molecular Biology	$43,693,896	$54,200,000	$51,100,000	$58,900,000	$7,800,000
Behavioral & Neural Sciences	19,689,189	24,400,000	23,600,000	28,300,000	4,700,000
Environmental Biology	26,838,481	32,550,000	30,550,000	33,600,000	3,050,000
Social Sciences	*18,813,848	21,500,000	*21,400,000	*24,000,000	*2,000,000
Total	$109,035,414	$132,650,000	$126,650,000	$144,800,000	$18,150,000

* Includes $300,000 for each year for the Man-In-The-Arctic Program formerly supported through the Astronomical, Atmospheric, Earth, and Ocean Sciences Activity.

Program Activity Goals and Description

The goal of the Biological, Behavioral, and Social Sciences (BBS) activity is to advance understanding and insure the continued scientific strength of the Nation by support of research which:

- augments knowledge of fundamental life processes, factors pertaining to man as an individual and as a member of society, and the behavior, organization and development of human societies and other biological communities;
- develops and maintains research resources, complex data sets and analyses, innovative techniques, and advanced methodologies to be used for further research, both fundamental and applied.

The Biological, Behavioral and Social Sciences are subdivided into four subactivities: Physiology, Cellular and Molecular Biology; Behavioral and Neural Sciences; Environmental Biology; and Social Sciences. The fundamental research supported by these subactivities contributes significantly to the NSF mission to strengthen the Nation's scientific research on natural and social phenomena. These phenomena range from the fundamental components of life, such as biomolecules, to the complex interactions of human life, studied in the social sciences. New possibilities for human development, increased options for improving the quality of life, greater opportunities for economic and social progress, and better development and utilization of resources are potential benefits of this research.

Explanation of FY 1978 Increases and Decreases

The Foundation's FY 1978 budget request for Biological, Behavioral and Social Sciences is $144.8 million, $18.2 million (14.3 percent) more than the FY 1977 level of $126.65 million. This increase will provide for the rising costs of conducting research and for new research opportunities in fundamental science. Basic research related to human development, ecology, food, energy, resources, inflation, and employment will continued to be emphasized.

Areas of science identified for continued or increased emphasis are:

Physiology, Cellular and Molecular Biology—Biochemical, cellular and physiological research in the plant sciences, in particular, photosynthesis, nitrogen fixation, experimental manipulation of plant cells, and plant response to stress; chromosome structure; genetics and differentiation; cell culture capabilities; containment facilities for biohazardous research; and methodologies and new instrumentation to extend the sensitivity of measurement in molecular biology. ($58,900,000 , an increase of $7,800,000 over FY 1977)

Behavioral and Neural Sciences—Support for studies of key aspects of behavior, including the nervous system, and the sensory systems; research on cognitive development and language acquisition in children; anthropological research, including more accurate dating technology; and more emphasis on social psychology in real life settings. ($28,300,000, an increase of $4,700,000 over the FY 1977 level)

Environmental Biology—Research on adaptation of plants to particular environments, especially genetic variability and disease resistance among healthy plant populations; and freshwater ecosystems and agroecosystems, with special attention to productivity, species composition, and nutrient cycling. ($33,600,000, an increase of $3,050,000 over FY 1977)

Social Sciences—Theoretical empirical studies pertaining to inflation, natural resources, unemployment and world trade; the development of machine readable data resources in sociology and political science; and comparison and validation of econometric models. ($24,000,000, an increase of $2,600,000 over FY 1977)

SCIENCE EDUCATION

FY 1978 Program Total $75,700,000

Summary of Obligations by Subactivity

Page	Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
	Science Manpower Improvement	$24,882,137	$24,700,000	$30,360,000	$29,700,000	$-660,000
	Science Education Resources Improvement	24,324,332	25,200,000	28,370,000	32,600,000	4,230,000
	Science Education Development and Research	10,932,128	11,700,000	11,250,000	8,200,000	-3,050,000
	Science and Society	2,342,083	3,400,000	4,320,000	5,200,000	880,000
	Total	$62,480,680	$65,000,000	$74,300,000	$75,700,000	$1,400,000

Summary of New Obligational Authority (NOA), Deferrals and Carryovers

Program Element	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
New Obligational Authority	$52,954,904	$55,000,000	$59,000,000	$75,700,000	$16,700,000
FY 1975 Carryovers	313,064	—0—	—0—	—0—	—0—
FY 1975 Deferrals	9,212,712	—0—	—0—	—0—	—0—
FY 1976 and Transition Quarter Carryovers	—0—	—0—	5,300,000	—0—	-5,300,000
FY 1976 Deferrals	—0—	10,000,000	10,000,000	—0—	-10,000,000
Science Education Program Activity Total	$62,480,680	$65,000,000	$74,300,000	$75,700,000	$1,400,000

Program Activity Goals and Description

The Foundation is authorized and directed to:

". . .initiate and support. . . .programs to strengthen. . . .science education programs at all levels. . . ." (PL 81-507).

The Science Education Program Activity is dedicated to this goal.

To achieve this goal, the Foundation supports a number of programs organized into four major subactivities. Each of these subactivities has objectives designed to contribute to the achievement of the Science Education Program Activity goal. The major subactivities and their objectives are:

Science Manpower Improvement—To identify and encourage scientific talent; to assist in the maintenance of high standards and quality in the training of students and professionals in the sciences; and to stimulate more participation in the sciences by minorities, women, and the handicapped.

Science Education Resources Improvement—To strengthen and improve the quality of science instruction and research training in schools, colleges, and universities and provide incentives for the use of validated knowledge and effective instructional strategies in science education.

Science Education Development and Research—To advance our knowledge of how scientific concepts, processes and skills are learned and to encourage the development of means by which the quality, relevance, and efficacy of the learning processes in science can be improved.

Science and Society—To bring about greater understanding of science and technology as it affects contemporary life including the social and ethical implications of an increasingly technology-dependent society.

The science education program elements within each subactivity have outputs or products which correspond to stated objectives. These are: (1) a flow of highly qualified scientific personnel who possess relevant scope and skills for employment in the public and private sectors; (2) improved capabilities of schools and institutions of higher education for research training and education in the sciences; (3) knowledge, instructional technologies, methods, and materials to increase the performance and productivity of the science education system; and (4) increased understanding and information about the role of science and society.

Explanation of FY 1978 Increases and Decreases

The Science Education Program Activity estimate for FY 1978 is $75,700,000. This represents an increase of $1,400,000 or 1.9 percent over the FY 1977 level, after accounting for deferrals and carryovers from prior years.

Several factors have affected the alignment of programs in the FY 1978 plan. Specific shifts in priorities can be seen in the change in funding pattern over the FY 1976 to FY 1978 period. These priority shifts are primarily in response to two influences. The first is the Congressionally mandated set of activities for improving: (1) the quality of instruction in schools and colleges in science; (2) opportunities for entry into science careers of disadvantaged individuals; and (3) the ability of the public to respond to issues bearing on the relationships between science and society. Since FY 1976 seven new program activities have been authorized to implement these concerns. They are:

1. Comprehensive Assistance to Undergraduate Science Education;
2. Research Initiation and Support;
3. Minority Centers for Graduate Education;
4. Seminars and workshops for Pre-College Teacher Development;

5. Expansion of Minorities and Women program to include the physically handicapped;

6. Research in Science Education; and

7. Science for Citizens.

In addition, the Ethics and Values in Science and Technology and the Continuing Education for Scientists and Engineers programs have been expanded in scope.

A further factor influencing FY 1978 program priorities has been the National Science Board's concern with the existing role of women and minorities in the Nation's scientific manpower pool. For example, in May 1976, the National Science Board passed a resolution requesting that programs and alternative approaches at the pre-college, undergraduate and post-baccalaureate levels be developed to involve more minority students in the study of science.

These new emphases, combined with the Foundation's review and restructuring of its Science Education Development and Research subactivity, resulted in a significant realignment of program priorities and a subsequent reallocation of resources as discussed in the subactivity descriptions which follow. Briefly, these subactivities are:

Science Manpower Improvement. A decrease of $660,000, or 2 percent, to a total of $29.7 million. An expanded program for minorities, women, and the physically handicapped in science is emphasized as well as an expanded program for high school students whose educational backgrounds have not been commensurate with their native ability. Efforts to make more effective utilization of postdoctoral scientists in meeting science-related national needs are also stressed. The Undergraduate Research Participation program has been reduced, and the funds are allocated to other support mechanisms for undergraduate education. The National Needs Traineeship program has been terminated and resources reallocated to the National Needs Postdoctoral Fellowship program.

Science Education Resources Improvement. An increase of $4.23 million, or 15 percent, to a total of $32.6 million. The new Minority Graduate Centers program element, established in FY 1977, is located in this subactivity, as are Comprehensive Assistance to Undergraduate Science Education (CAUSE) and Research Initiation and Support (RIAS) which were established in FY 1976. Growth in the CAUSE program accounts for most of the increase in the FY 1978 program. There is also an increase in the newly restructured Information Dissemination and Undergraduate Instructional Improvement programs. The Pre-Service Teacher Education program will be terminated as a program subelement, since such efforts are eligible for support under the Comprehensive Assistance to Undergraduate Science Education program and the Local Course Improvement program.

Science Education Development and Research. Research in Science Education remains approximately level, while Development activities are decreased, resulting in an overall reduction of $3.05 million, or 27 percent, for a total FY 1978 level of $8.2 million. This reflects the need to obtain more factual information about needs and trends to provide a firm foundation for subsequent development activities, the completion of several large development projects, and a sharpened emphasis on prototype projects prior to full-scale development efforts. While the Technological Innovation in Education program element has been discontinued as a separately identified activity, this type of support is possible in the other Development subelements and in the Research element as appropriate.

Science and Society. The increase of $880,000, or 20 percent, to a total of $5.2 million for this subactivity, reflects primarily the augmentation of the Public Understanding of Science program in response to Congressional recommendations. Smaller increases are accorded both the Science for Citizens program element, which was established by the Congress in FY 1976 and first funded in FY 1977, and the Ethics and Values in Science and Technology program element.

RESEARCH APPLIED TO NATIONAL NEEDS

FY 1978 Program Total $78,000,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
Resources	$15,201,436	$10,000,000	$10,000,000	$11,500,000	$1,500,000
Environment	26,981,970	24,500,000	24,900,000	34,500,000	9,600,000
Productivity	24,107,868	24,400,000	23,400,000	23,000,000	-400,000
Intergovernmental Science & R&D Incentives	4,335,764	4,600,000	7,900,000	7,000,000	-900,000
Exploratory Research & Technology Assessment	1,399,659	1,400,000	1,400,000	2,000,000	600,000
Total	$72,026,697	$64,900,000	$67,600,000	$78,000,000	$10,400,000

Program Activity Goals and Description

The Foundation's program of Research Applied to National Needs (RANN) focuses U.S. scientific and technical resources on selected problems of national importance for the purpose of contributing to their timely, practical solution.

The objectives of RANN are to:

- Increase the effective use of appropriate science and technology in dealing with national problems involving the public interest;
- Shorten the lead time between basic scientific discoveries and relevant practical applications; and,
- Provide early warning of potential national problems and initiate assessments and research useful in avoiding or solving such problems.

RANN is organized around five problem areas: *Resources, Environment, Productivity, Intergovernmental Science and Research and Development Incentives,* and *Exploratory Research and Technology Assessment.*

The objective of the *Resources* subactivity of RANN is to develop strategies and new technologies which can lead to more effective utilization of renewable and nonrenewable resources in the national interest. The objective of the *Environment* subactivity is to enhance the Nation's capability to mitigate environmental hazards, whether natural or man-caused. The objective of the *Productivity* subactivity is to help improve the total factor productivity of the public and private sectors of the economy.

Considerable flexibility exists in supporting research that cuts across these three interrelated areas.

The objectives of the *Exploratory Research and Technology Assessment* subactivity are to provide better understanding of the long-range social, environmental, and economic consequences of new technology applications and to identify and analyze emerging national problems which might be avoided or ameliorated by applications of the appropriate science and technology. In a sense, this subactivity provides an "open window" to the scientific community to explore innovative ideas that might form the basis of new problem-focused programs within RANN.

The *Intergovernmental Science and R&D Incentives* subactivity seeks to encourage the effective integration of science and technology into the policies and programs of State and local governments. The second objective is to test selected incentives which the Federal Government may properly use to increase R&D investment in the private sector where new technology is needed in the national interest. Particular attention is given to small business and to fragmented industries.

Each of these subactivities focuses on problem areas important to the well being and strength of the Nation. Each is also highly complex and interrelated, and this creates both an opportunity and a requirement for the multidisciplinary, problem-oriented research which is characteristic of RANN. For these reasons, the RANN program follows a best performer policy, utilizing, as appropriate, the best scientific and technical skills in universities, national laboratories, and industry.

The problems selected for attention by RANN share several characteristics in accordance with the following criteria: (1) they have important national significance; (2) the payoff of research is expected to significantly exceed the costs of research on the problem; (3) the leverage of science and technology on the problems is substantial; (4) the efforts are timely and scientifically ready; (5) academic, industrial, and Federal capability exists to mount a successful research program; (6) there is a need for Federal action in that the required research on the problems would not likely be generated by normal market forces; and (7) NSF is in a unique position to serve the objectives of the Government in that the problems addressed by RANN either overlap the boundaries of several mission agencies, fall between the boundaries of the charters of mission agencies, or meet the longer range needs of one or more agencies.

Problem areas receive attention by RANN only after they have been examined extensively by leaders in the scientific and the user communities. RANN has supported hundreds of conferences and workshops, involving tens of thousands of experts from industry, labor, government, and universities, to assure that major emerging problems and the highest potential payoff in exploiting scientific and technological opportunities for resolving the problems are identified. RANN's Research Applications Policy Advisory Committee (composed of outstanding experts from universities, industry, labor, State and local government, and the public interest area) advises on priorities among problem areas and means for dealing with them. Research areas of particular importance to State and local government have been identified through such mechanisms as the RANN-supported Urban Consortium, the Urban Technology System, and State problem identification studies. Special conferences and workshops involving labor and industry, both large and small, have been held to obtain inputs from these sectors on the RANN program. All of these inputs play a key role in planning the RANN program. Problem areas appearing in the FY 1978 budget request have all undergone examination by these processes.

Upon determination that a problem area meets the criteria for consideration by RANN, a detailed program plan is developed to identify the resources and the timing of research activities needed to assure that the research will proceed in an effective manner to achieve the specified objectives. Program plans are based on the best judgments available concerning the state of the science; the capacity of the scientific community to mount the effort, and the most cost-effective investment stream for achieving the objectives. Milestones are built into all plans so that progress toward the achievement of objectives can be tracked. Ultimately, program objectives are attained when the research has been brought to the point where it can be transferred to the user community, including other public agencies and industry.

Explanation of FY 1978 Increases and Decreases

The total amount requested for the RANN Program in FY 1978 is $78,000,000, or $10,400,000 above the planned program of $67,600,000 for FY 1977. This increase is required to assure timely and cost-effective attainment of established objectives.

Resources is increased by $1,500,000, from $10,000,000 to a new level of $11,500,000. This increase will permit essential acceleration of research on renewable resources, particularly in the areas of nonconventional foods and biomass utilization. This research is aimed at enhancing the Nation's ability to produce food from nonconventional sources on an economically competitive basis and at obtaining more effective use of relatively plentiful renewable resources for chemicals and other commercial purposes.

The increase of $9,600,000 from $24,900,000 to $34,500,000 in Environment permits new and expanded research on earthquake engineering and on utilization of earthquake engineering research results. The increase in this area is based on findings in a recent report to the President entitled, *Earthquake Prediction and Hazard Mitigation*. Research on such cross-hazard issues as post-disaster audits and integrated disaster warning systems will also be accelerated to permit timely achievement of essential objectives.

The Productivity subactivity decreases from a planned level of $23,400,000 in FY 1977 to a requested level of $23,000,000. This $400,000 reduction results largely from the planned transfer to the Department of Commerce of several research activities concerned with urban service delivery technology.

The decrease of $900,000 in the Intergovernmental Science and Research and Development Incentives subactivity from $7,900,000 to $7,000,000 has several components. In FY 1977, the Foundation is funding a special, one-year State Science, Engineering, and Technology (SSET) program at a cost of $3,000,000. Partially offsetting the decrease of $3,000,000 for the SSET program is $2,100,000 to permit the following: (1) a thorough evaluation, as recommended by the Congress, of the results of the FY 1977 State Science, Engineering, and Technology study program, (2) additional experiments on institutional mechanisms for encouraging the use of science and technology at the local level, and (3) continued expansion of emphasis on strengthening research and innovation in small R&D businesses and the expansion of the multiproject experiment on regional research centers.

The increase of $600,000, from $1,400,000 to a new level of $2,000,000, in Exploratory Research and Technology Assessment will permit research on the major problems and issues associated with the current transition in the United States from a more production-oriented, throw-away economy to a more service-oriented, closed cycle economy.

SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS

FY 1978 Program Total $22,600,000

Summary of Obligations by Subactivity

Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978-77
International Cooperative Scientific Activities	$7,528,958	$8,700,000	$8,700,000	$10,500,000	$1,800,000
Science Information Activities	5,894,722	6,000,000	5,000,000	5,000,000	—0—
Science Assessment, Policy & Planning	8,986,503	7,300,000	6,900,000	7,100,000	200,000
Total	$22,410,183	$22,000,000	$20,600,000	$22,600,000	$2,000,000

Program Activity Goals and Description

The Scientific, Technological and International Affairs (STIA) program activity combines those Foundation programs that are designed to address a broad range of scientific and technological issues of concern to policymakers and R&D managers in the public and private sector. In its broadest terms, the overall goal of STIA is to enhance the contribution of the scientific and technological enterprise to the social and economic goals of the Nation. STIA supports those essential activities which relate the accomplishments and potential of the science and technology sector to broad national objectives. Because of the growing importance of science and technology in contemporary foreign policy, the Foundation, given its broad authority in the area of international cooperation, is called upon by the Department of State to assist in carrying out international scientific programs on behalf of the U.S. Government. Science Information activities within STIA provide the only source of Federal funds for generalizable research on ways of improving access to and increasing use of information across all fields of science. Stemming from its legislative mandate to evaluate the status and needs of various sciences, appraise the impact of research, and provide information for policy formulation, the Foundation maintains a strong interest in the resources available for science and technology, and in the quantity, quality and direction of the U.S. scientific and technological research effort. Activity objectives are pursued through three program subactivities: International Cooperative Scientific Activities; Science Information Activities; and Science Assessment, Policy and Planning.

The International Cooperative Scientific subactivity strengthens U.S. science and technology (S&T) by supporting mutually beneficial interactions between U.S. and foreign scientists. It provides the key support for U.S. researchers cooperating with foreign experts and for many joint international scientific and technological activities. The Foundation supports 21 bilateral cooperative science programs involving joint research, seminars, and scientific visits, and participates in the scientific and technical activities of seven Joint Commissions for Economic Cooperation. Scientific activities supported under this program subactivity not only serve the needs of U.S. science but also further the foreign policy interests of the United States.

The Science Information subactivity is designed to increase the effectiveness of research and engineering through productive use of the growing body of scientific and technical information. It stimulates and supports efforts aimed at improving the accessibility and use of scientific and technical information. It also enables the Foundation to meet its statutory responsibility for fostering the exchange of scientific information among scientists in the United States and abroad, arranging for services to provide effective dissemination of scientific information, and undertaking programs to develop new or improved methods for making scientific information available.

The Foundation's Science Assessment, Policy and Planning subactivity provides data and analyses pertaining to the Nation's S&T activities and identifies existing and emerging national issues with significant science and technology policy content. This information contributes to the improvement of policies relating to domestic and international R&D and the uses of technology, and to planning and policy formulation, especially in the area of S&T resources. Specific areas of program emphasis include the following:

(1) National R&D funding patterns, the relationship between Federal and private sector R&D, and the national scientific, engineering and technical manpower systems with special emphasis on supply and utilization;

(2) The innovative processes in the private sector, the relationship between Federal policies and technological innovation, the socioeconomic effects of technological innovation, and the role of science and technology in international relations;

(3) The planning, evaluation and analysis of NSF activities.

Explanation of FY 1978 Increases and Decreases

NSF has received advice and requests from the Executive Offices of the President, the Congress, other Federal agencies (especially the Department of State) as well as nongovernmental organizations. The requested increases for FY 1978 are responsive to these needs and priorities which require a higher level of investment if STIA is to meet its international commitments and its obligations to supply objective data, information and analyses that can improve the policy formulation and decision processes with regard to science and technology.

Of the total increase of $2.0 million requested for STIA, it is proposed that the International Cooperative Scientific Activities be increased by $1.8 million, an indication of the growing importance of such activities to both U.S. science and foreign policy. A large fraction of this increase is requested for a major nonrecurring international activity—$1.1 million will permit the Foundation to fund government-wide preparations for the U.N. Conference on Science and Technology planned for 1979 or 1980. $400,000 will support the announced dues increases and related administrative costs for U.S. participation in nongovernmental international scientific organizations. The remaining $300,000 for international programs is requested to support initiation costs for three or four new bilateral S&T agreements to be executed during FY 1977, and to offset higher costs for scientific exchange programs. The existing bilateral programs remain level-funded.

The $200,000 increase for Science Assessment, Policy and Planning requested for FY 1978 will be used to continue and upgrade the regular, periodic surveys necessary to maintain the national R&D data base; to provide for special analyses and evaluations aimed at increasing the utility of the data base; and to conduct special analytical studies of issues currently of greatest concern to Federal policymakers. No increase is planned for Science Information Activities until the results of the comprehensive review of this subactivity are available. The details justifying these increases and descriptions of the specific purposes for which they will be used are contained in the special sections, "Explanation of Increases and Decreases" in the subactivity sections of the budget.

PROGRAM DEVELOPMENT AND MANAGEMENT

FY 1978 Program Total $47,825,000

Summary of Obligations by Subactivity

Subactivity	Actual[1] FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978-77
Mathematical and Physical Sciences and Engineering	$5,315,956	$4,520,000	$4,882,000	$5,007,000	$125,000
Astronomical, Atmospheric, Earth and Ocean Sciences	3,957,673	4,186,500	4,376,000	4,490,000	114,000
Biological, Behavioral and Social Sciences	1,550,649	2,719,000	3,155,000	3,466,000	311,000
Science Education Programs	3,276,330	2,888,000	2,978,000	3,203,000	225,000
Research Applied to National Needs	4,120,099	4,289,500	4,517,000	4,648,000	131,000
Scientific, Technological and International Affairs	4,349,472	5,446,000	5,493,000	5,605,000	112,000
Executive Management	5,084,137	5,410,000	5,757,291	6,099,000	341,709
Central Support Services and Administration	14,571,705	14,041,000	14,630,000	15,307,000	677,000
Total	$42,226,021	[2]$43,500,000	[3]$45,788,291	$47,825,000	$2,036,709
Position Ceiling	1,300	1,300	1,300	1,325	25

[1] Obligation levels between FY 1976 and FY 1977 are not entirely comparable due to reorganization of Directorates during FY 1976.

[2] Does not include costs of the October FY 1976 pay raise.

[3] Includes proposed supplemental for the costs of the October 1976 pay increase.

Program Activity Goals and Description

The Program Development and Management (PD&M) activity provides for the operation, support, management and direction of all NSF programs and activities previously described, and includes necessary funds to develop, manage, and coordinate these program activities. It includes salaries and operational expenses of NSF staff and all expenses of the National Science Board.

Over the past several years, the Foundation has undergone a major reorganization, which realigned the organizational structure to carry out current program responsibilities more effectively and to provide a more efficient and flexible structure for meeting new and changing program management requirements and initiatives.

The current organizational structure consists of six program directorates and an Administration Directorate together with five staff offices reporting to the Director. The six program directorates are directly concerned with the operation and management of one or more major discrete segments of the Foundation's overall science programs. Basic research is strongly represented at Foundation top management level by three assistant directors, each representing related groups of scientific disciplines. Major applied research activities are identified and grouped

87-769 O - 77 - 6

in the Research Applications Directorate. Science education programs are managed under a separate directorate. International programs, science information activities, and the Foundation's policy analytical activities and science resources studies are consolidated into a single directorate so that these functions can be coordinated and integrated more efficiently within the agency. The staff offices reporting to the Director are the Planning and Resource Management function, Equal Employment Opportunity, Government and Public Programs, the General Counsel and the recently established Office of Small Business Research and Development.

Explanation of FY 1978 Increases and Decreases

The FY 1978 estimate of $47,825,000 for Program Development and Management is an increase of $2,036,709, or 4.4 percent, over the comparable amount included in the FY 1977 Current Plan.

The total FY 1978 estimate will permit only moderate increases in selected expense categories. Staffing will increase from 1,300 permanent positions to 1,325. Twenty-five new positions initially funded on a part-year basis will be distributed as follows:

- Ten positions will be assigned to the Directorate for Biological, Behavioral and Social Sciences to provide personnel resources to manage the expanding size, complexity, and scope of the programs in this Directorate.
- Eight positions will be assigned to the Science Education Directorate to assist in developing and managing programs required by Public Law 94-471, the FY 1977 National Science Foundation Authorization Act, which directs the Foundation to conduct a number of new or expanded science education programs such as Science for Citizens, Continuing Education in Science and Engineering, and programs for Minorities, Women and Handicapped Individuals.
- Seven positions will be assigned to the Executive Management functional area to provide the additional staff resources required for more intensive evaluation of Foundation programs, studies of broad issues effecting future policy decisions, and for initial staffing of the newly established Office of Small Business Research and Development.

Included in the overall FY 1978 estimate are additional personnel compensation funds which will allow for maximum utilization of existing permanent positions by increasing the average paid employment.

Detailed increases include:

- $489,000 for personnel compensation and benefits to cover initial funding of the 25 new positions. This amount is approximately three fourths of the average annual cost and will include phasing in of the positions during the year. The balance of the cost will be annualized in the FY 1979 budget.

- Approximately $600,000 more permanent personnel compensation funds is budgeted in FY 1978 than in the FY 1977 current plan to permit maximum utilization of existing positions. The average length of time during which positions are vacant will be decreased having an overall effect of increasing the average paid employment by 24.
- Travel for both staff and consultants is increased by $200,000 or 8.3 percent. Due to higher fares, the increase will maintain only approximately the same level of travel that is budgeted for the FY 1977 Current Plan.
- Space rental is increased by $205,000 due to adjustments in the General Services Administration assigned Standard Level User Charges and for higher rental costs in exchange space. No funds are included in the estimate for additional space.
- Telephone and postage are increased by a total of $180,000 due to higher telephone charges assessed by the General Services Administration and postal rate increases. Offsetting this increase is a reduction of $120,000 in data processing rentals. Purchases of data processing equipment in FY 1976 and in FY 1977 will reduce rental charges in FY 1978.
- Other Contractual Services is increased by $185,000 due mainly to higher Federal salary rates being passed on the Foundation by agencies providing contract services.
- Equipment purchases are increased by a net total of $125,000 to provide the necessary office furniture and other equipment for the 25 new positions and also continue the Foundation's long-range plan for replacing worn out and obsolete equipment.

SPECIAL FOREIGN CURRENCY PROGRAM

FY 1978 Program Total $6,000,000

Summary of Obligations by Subactivity

Page	Subactivity	Actual FY 1976	Budget Request FY 1977	Current Plan FY 1977	Estimate FY 1978	Difference FY 1978/77
J-I	Research and Related Activities Program	$4,163,508	$4,800,000	$3,883,697	$4,900,000	$1,016,303
J-II	Science Information Program	238,538	1,200,000	1,100,000	1,100,000	—0—
	Total	$4,402,046	$6,000,000	$4,983,697	$6,000,000	$1,016,303

Program Activity Goals and Description

The Special Foreign Currency Program Activity uses U.S.-owned foreign currencies designated by the Department of the Treasury as excess to the requirements of the U.S. Government. In this way, the National Science Foundation is able to finance scientific activities of benefit to the United States and participating foreign countries, without exporting dollars. The objectives of the overall activity are pursued chiefly through grants for research and related activities and contracts for the translation into English of technical literature from foreign languages. These grants and contracts support:

- Participation by U.S. scientists and institutions in international cooperative science projects. This promotes science in the United States and benefits both of the cooperating parties.
- Translations of scientific and technical literature.

Explanation of FY 1978 Increases and Decreases

The proposed program for FY 1978 totals $6,000,000 which represents an increase of approximately $1,000,000 over the current program for FY 1977.

The total increase is designated for Research and Related Activities. This reflects significant expansion of programs because of new Joint Commission activities in India and Egypt, and an increase in cooperative projects in Pakistan. The costs of these new efforts will be partially offset by the termination of programs in Poland and Tunisia, brought about by the recent removal of these countries from the Treasury Department's "excess currency" list.

The allocation for Science Information Activities is unchanged. NSF's contribution is matched by other U.S. agencies which contribute about $1.9 million in Special Foreign Currencies to the total translation program.

RECENT MANAGEMENT ACTIONS

During fiscal years 1975 and 1976, the Foundation revamped a substantial segment of its administrative structure and procedures. In the summer of 1975, it undertook a major reorganization, creating six program directorates and the Directorate for Administration. Substantial internal restructuring of the directorates has also been accomplished. The reorganization, among other things, established the biological, behavioral and social sciences on an equal organizational level with other disciplines and consolidated formerly separate programs in fields such as the astronomical sciences and policy analysis.

Peer review procedures have been strengthened. The Foundation has issued guidelines for the selection of reviewers and for instructions to reviewers. It has also defined new policies for the release of proposal information to applicants. To provide applicants with an appeals mechanism, a formal reconsideration procedure has been initiated. To ensure adequate review of the proposal evaluation process, Action Review Boards have been established in each program directorate. A Director's Action Review Board now reviews recommended awards before they are submitted to the National Science Board. An ad hoc committee of the National Science Board has reported favorably on the performance of the Action Review Boards.

NSF has also taken a number of other actions designed to increase its accountability to the public and Congress. New grant reporting requirements have been established which provide timely receipt of abstracts of the results of NSF supported research and that all substantive technical reports will be made available through the National Technical Information Service (Department of Commerce). New issuances also standardize the paperwork associated with an award and redefine and simplify the categories of NSF grants. To provide Foundation staff, particularly program offices, with improved access to Foundation policy and procedures, NSF recently issued a *Handbook for Program Officers*.

During the coming fiscal year, concentration will be on implementation of changes planned or underway, for example, receipt of final fiscal and technical reports and monitoring and evaluating changes completed. The Foundation will need to maintain a close scrutiny of the proposal evaluation process, especially the role and functioning of the Action Review Boards. The National Science Board has established a Committee on Mechanisms for Improved Policy Formulation and External Communications, chaired by Dr. W. N. Hubbard, Jr., President of the Upjohn Company, to maintain oversight of administrative initiatives within the Foundation.

Senator KENNEDY. Thank you very much, Mr. Atkinson.

Some of these matters you touched on are especially interesting but I thought I would hold some of the questions until you finished your comments.

Let me ask you now about what effort has been made to include nonscientists and precollege science educators in the next list of Board nominees which will be submitted to the President?

Has there been any effort in those areas?

Dr. HACKERMAN. We have looked at a variety of lists. I would like to ask Dr. Nierenberg, who chairs our ad hoc committee on NSF staff andNSB nominees, for Board members and others, to respond.

Dr. NIERENBERG. We looked very seriously at this question. Mr. Chairman, and consulted very widely. I presume we are talking about members of the Board; is that right?

Senator KENNEDY. Yes.

Dr. NIERENBERG. Eight vacancies will occur in May 1978. However, we have decided to start quite early, partly in response to this particular viewpoint.

Our list does contain names of persons we have defined as public members. We have been rather careful about this, Mr. Chairman. I say "we," I am talking about current members of the Board, past members of the Board, and others whom we have consulted very widely. As Board members, we are not simply an advisory committee. We also have serious executive responsibilities in precisely many of the questions that you outlined, all of them with very important priority and budgetary implications. This requires a high degree of expertise, sensitivity, and talent between very different disciplines.

One of the results is that, while we welcome additions to the Board in the sense of public members, I think we possibly defined them more narrowly at the moment. We define them as permanent, public individuals who have had considerable experience in government matters and public matters, but are not specifically technical or scientific people. These are the kinds of names we are considering.

We also are reviewing the entire statute regulating our choice of members and our own historically perceived basis for members to try to formulate this new policy, in line with our other requirements—geographical, disciplinary, administrative, and so on—realizing in the end we are limited by the number 24 to cover all of these great varieties.

Senator KENNEDY. There is nothing that you said that I differ with. But I will say I do not see how the point that I am making runs contrary to what you have suggested.

Of our 24 Board members now, how many do you have precollege science educators? Do you have any?

Dr. HACKERMAN. No.

Senator KENNEDY. I think this is an area, as we have seen over a period of time, which I think is extremely important. This is particularly true when you are talking about interesting young people in science and science education, particularly getting women and other minority groups involved. It is an area which needs to be represented. I just know, in terms of my own State, that there are some really outstanding precollege science educators that have been sources of enormous inspiration to individuals in going into these areas.

The 1950 National Science Foundation Act also calls for people in public affairs to serve in the Board. It seems to me that there are knowledgeable people available. We have some on our OTA panels. We include on those panels people who have public affairs interest and they, in many instances, have been the most active and interested panel members.

It seems to me that those are things that ought to be considered. I am mindful of the enormous responsibility that the Board has in looking over the budget of approximately $900 million. I suppose you could ask whether people who are busy as the Board members are and who have the responsibilities that many of them have can be effective. Even with the staff support that they may serve on a part-time basis.

The Board members are enormously busy. They deal with very complex issues. But this should not include public members or those that are involved in the precollege science serving on the Board. I think that is an issue which is an important one and which we ought to give consideration to.

Do you have any ideas on that?

Dr. ATKINSON. Senator Kennedy, let me augment that remark by saying that the Foundation, as you well know, and with good advice from your office has set up an advisory council of 24 members, not in any sense to replace the National Science Board but to supplement its deliberations, particularly on a longer term basis.

Five members of that Council are nonscientists, including three strongly identified with public affairs. In addition, nine other Council members, while having a science background, currently are active in careers that encompass the arts, the humanities, or other nonscience activity as well.

The Council will have its first meeting this spring. I might tell you that we invited 24 individuals to join the Council. All 24 of our first choices accepted invitations.

Senator KENNEDY. I think it would be worth while for nonscientists to serve on the Board itself, with all the preeminence that it has. How does the Board function and relate to its responsibility? It meets just 2 days a month—what is the attendance record of that Board?

Dr. HACKERMAN. Generally, 21 out of 25 at the very least.

Senator KENNEDY. That is excellent.

Dr. HACKERMAN. It is quite good.

Dr. NIERENBERG. I would like to respond to the first two points.

Senator KENNEDY. You do better than congressional committees on attendance.

Dr. NIERENBERG. Mr. Chairman, from the viewpoint of everyone with whom I have discussed the matter, precollege science educators would be, in our view, completely appropriate as Board members and would be found on our list.

The second one is really in agreement with what I was trying to say.

You were suggesting some precision in public affairs, public representatives, the sort of people involved with the Office of Technology Assessment. I would agree also. Normally I would not want to mention names, but I would say someone as distinguished as Emilio Daddario would be considered eminently qualified as a public representative.

I am talking about "we" on the basis of the consultation we have made.

The third point is about busy Board members. In consideration of any appointment to committees of this type, you are always caught in the dilemma that the people you want are always the busiest. The question is, how do you compromise available time versus quality being sought.

Dr. HACKERMAN. This Board is busy, Senator; but they do work very hard.

Senator KENNEDY. We are very interested in the ethics provisions which were included in your authorization last year.

In the fiscal year 1978 budget what funds are provided to train persons with special skills needed to carry out studies on ethical and value implications in technology. Can you talk about that for a moment, what provision exists in the 1978 budget on that?

Dr. ATKINSON. It is a small dollar amount.

Senator KENNEDY. About $500,000?

Dr. ATKINSON. I will turn to Dr. Averch and let him comment on that.

Dr. AVERCH. The total request is $1.4 million. Some of those funds are clearly for training of individuals who might want to work in the field. I do not think that is our entire budget, because some of the proposals that we get in other programs deal with ethical and value questions, and for training undergraduates or, on occasion, graduates in these issues.

So our total program budget would be somewhat larger than the $1.4 million.

Senator KENNEDY. I am particularly interested in that.

Could you give me a note on that; what you are doing, what you plan to do on that?

Dr. AVERCH. Yes.

Senator KENNDY. That would be fine.

[The information referred to follows:]

Senate Authorization Hearings
March 1, 1977
Insert - Page 40

The primary focus in the Science Education Directorate for proposals concerned with the ethical and value implications of science and technology is, of course, the Ethics and Values in Science and Technology (EVIST) Program in the Science and Society subactivity. Some examples of recent EVIST awards are:

o Five humanists drawn from philosophy and literature are working in the laboratory, seminars, and symposia, with five scientists engaged in research in molecular biology, behavioral genetics, developmental psychology, earthquake prediction, and solar energy, in order to develop criteria and standards to identify and assess the ethical and value dimensions of their research.

o Biological researchers and philosophers work to build a bridge between biologists' environmental concerns and philosophers' ethical investigations by analyzing ethical dilemmas with respect to the interests of presently existing and future persons in the areas of (1) the green revolution, (2) genetic engineering, (3) exploitation of oceans, and (4) climate alterations.

o An interdisciplinary scholarly study involves analysis of the many documents and issues surrounding a case in which three engineers, concerned for the safety of an automatic train control system, were dismissed. This analysis and careful interviews of all principals to the case (the engineers, management of the organization, professional and technical societies, the executive, legislative and judicial branches of goverment) will be used to generate (1) a set of case study materials for classroom use, (2) a brief monograph for general readership, and (3) short articles for scholarly and popular publications.

In addition to the formal EVIST program activity, proposers may include ethical and value concerns as part of proposals submitted in program competitions in all three of the other Science Education Program subactivities. Some examples of recent awards which involve ethics and value concerns are:

Science Manpower Improvement. Since the early years of the College Faculty Short Courses Program, ethics and value issues have been prominent. In the current series of short courses there are lectures on such topics as Ethical Issues and the Life Sciences; Privacy and Problems of Law, Morality and Technology; Genetics and Society - A Dynamic Interaction; and Environmental Impact and Conflict Resolution.

In the Science Faculty Professional Development Program the study and research plans of fellowship holders in FY 1976 included such ethics and value-related topics as population policy issues, biosocial issues of genetic and health counseling, and changes in values during times of social crisis.

The Student-Originated Studies (SOS) Program, which involves groups of undergraduate science and engineering students in independent research experiences, has also received proposals involving ethics and values concerns. Some recent SOS project awards which included ethics and values questions are: the impact of industrialization of a community, forecasting potential social conflicts, site study of nuclear waste disposal, social impact assessment of an interstate highway, and changes in the quality of life.

<u>Science Education Resources Improvement</u>. In the Comprehensive Assistance to Undergraduate Science Education (CAUSE) Program, two recent awards included the creation of seminars for seniors to consider present and future societal problems and, in particular, those science issues affecting the future.

The Local Course Improvement (LOCI) Program which supports individual faculty or a small group of faculty members' efforts to improve a specific course offering frequently involves the introduction of ethics and values questions into the undergraduate curriculum. Some examples of recent LOCI awards are:

- o Development, implementation, and evaluation of six ethics/values add-ons for existing biology and psychology courses;
- o Development of chemistry modules for non-science majors which will include modeling and simulation with computers involving issues encountered in decisions on population, food supplies and food technology, energy resources and alternatives, quality of environment, and chemical technology and industries; and
- o A sequence of special courses and support material for an established curricula which will develop awareness, theory and concepts, as well as methodology and field research on culture-specific relationships between the built environment and the communities of people it is intended to serve.

Senator KENNEDY. In the Science for Citizens program there have been concerns that funding for citizens groups expect cause delay in Government decisionmaking. I am mindful of the Boasberg Report done for NSF on the impact of funding for citizens groups. Mr. Boasberg found that there is no evidence of delay resulting from citizen activity in the environmental area, even after 6 years of various law suits.

I am wondering whether you agree now that this argument against direct funding ought to be put to rest.

Dr. AVERCH. Senator Kennedy, I think we should put the question to the direct test and take a look at and evaluate public service science residencies and internships. There has been a good deal of debate, as you know; not so much about public understanding of science projects but about funding so-called intervenors.

We are not proposing this year to experiment with direct intervention, but with essentially public understanding kinds of questions called for in the legislation. We are prepared to go ahead; and in fact the National Board has approved the program guidelines for this year. We should be seeing proposals soon. Then I think we will be able to put the question to rest once and for all.

Senator KENNEDY. That is encouraging.

You obviously do not provide direct funding to any groups. You provide technical information, forums for interested groups?

Dr. AVERCH. That is correct.

There has been some concern, though, that intervenors or advocacy groups could use that information, could perhaps get access to it more rapidly than the public and could conceivably bias the proceedings.

We are suggesting that in whatever projects we do fund, either conferences and workshops or residencies, that information from those projects be disseminated as widely and as rapidly as possible.

Senator KENNEDY. In the international programs which I mentioned very briefly in my opening comments, would you like to comment on what is being done whether in health or nutrition or food production.

Is there anything you want to say on this?

Dr. ATKINSON. Senator Kennedy, there is a long story here. I would like to introduce into the record some 20 items that we have called out as notable successes in our international program.

(The information referred to follows:)

International Cooperative Programs: Some Recent Achievements

1. Polish and U.S. scientists have designed a novel instrument to measure the contact angle, between liquid and solid surfaces, more accurately and reliably than by earlier methods. This measurement is fundamental to many industrial processes. (SFC RRA)

2. The control of obesity, a major world-wide health hazard, is now better understood owing to the discovery by U.S. and Australian scientists that a metabolic hormone, norepinephrine, is released by the nervous system when food is eaten. (U.S.-Australia)

3. Photorespiration, a light dependent process in plants that interferes with photosynthesis and productivity, is now known to occur in marine plants as well as land plants. This finding by U.S. and Australian scientists is significant to mankind because of the major role of marine plants in the world energy balance. (U.S.-Australia)

4. When humans and other mammals are born, their lungs must instantly adapt to an air-breathing habit. Using concepts from Italy with experimental methods refined in the United States, scientists of both countries have discovered that proteins contribute to lung stability during these fragile moments. (U.S.-Italy)

5. The International Institute of Applied Systems Analysis, for which NSF pays the U.S. membership dues, is located near Vienna, Austria. A symposium held in Warsaw, Poland, in June 1976, led to definition of a common international framework for scientists of 12 countries in the field of computer-based economic planning. (International Org.)

6. Because USDA had access to Russian literature under the NSF-coordinated SFC science Information Program, Bell Laboratories was provided with a highly efficient new design of a "sea plow" for trenching transoceanic cable. (SFCSI)

7. U.S. and Kenyan botanists collaborated in Nairobi on a study of the drought-resistant characteristics of six varieties of finger millet and three local vegetables. This information is urgently needed to increase tropical agricultural productivity. (SEED)

8. An important and pressing set of socio-economic and political problems in our Southwest is related to population migrations within Mexico and from Mexico to the United States. For the first time sufficient data have been collected to enable systematic predictions useful to decision makers in both countries. The existence of a formal, intergovernmental agreement was necessary to release the data. (U.S.-Mexico)

9. A U.S. university could not have started research with its new cyclotron facility without Australian instrumentation and data processing. (U.S.-Australia)

10. Plants belonging to the buttercup family appear to contain a wealth of antibacterial substances new to science. (U.S.-Japan)

11. A Soviet scientist visited a U.S. scientist who was working in a field far removed from his main interests. In comparing notes, they quickly and unexpectedly found that they could devise a radically new way to determine the nucleotide sequence in DNA. (ISS)

12. Using temperatures close to absolute zero (minus 459 deg. F.) U.S. and Brazilian scientists have slowed down the motion of molecules in order better to understand their behavior at surfaces. In studies of the adsorption of helium molecules at graphite surfaces, the low temperatures also kept the surfaces extremely clean for longer periods. The joint project of Stevens Institute of Technology, New Jersey, and the Federal University of Rio de Janeiro has produced basic data regarding surface structure and energy changes, needed by other experimenters in basic science. The data are also useful to engineers who design such solid state elements as transistors and solar energy devices. (U.S.-Brazil)

13. It is no accident that all the crystals in the sugar bowl are the same size. The control of crystal size (for marketability or usefulness in chemical processing) of pure substances was investigated by U.S. and Australian scientists by means of computer models. They devised a process for continuous (rather than batch) production of uniform sugar crystals that is a major theoretical advance widely applicable in the chemical industry. (U.S.-Australia)

14. A new concept of the reaction of chlorine gas with metallic silver surfaces has resulted from the collaboration of U.S. and Italian materials scientists. Scientists of SUNY/Stony Brook were experienced in studies of the structure of clean metal surfaces; those at the University of Florence had studied chemical reaction mechanisms of metals with gases. As a by-product, they developed new theory applicable to low-energy electron diffraction, a powerful method for the study of metal surfaces. (U.S.-Italy)

15. A major oceanic current, not wind, is responsible for marine upwelling in the Southwest Pacific Ocean. The current, the Kurushio, flows from The Philippines past Taiwan to Japan. As it changes course, it causes the upwelling of deep, nutrient-laden water to the surface, with profound consequences for fishery resources and other marine life. This important ecological link to the Kurushio was discovered by U.S. and Taiwanese scientists. (U.S.-ROC)

16. A fragment of the complex molecule that regulates calcium levels in the body has been totally synthesized for the first time as the result of a 6-week visit of a young scientist to Australia. The unusual success of the visit was attributed to careful planning and shared skills. (International Travel Support)

17. Compilation into tables of experimental data about the positron, a kind of short-lived atomic particle, is expected to lead to better understanding of chemical processes, the conduction of electricity by metals, and other basic properties of matter. The data represent 33 years of effort by atomic physicists all over the world. The tables were jointly compiled by physicists from the United States and India. (SFC RRA)

18. For two years, U.S. information scientists had tried to solve a general problem dealing with the transmission of digital information over communication channels that have "memory," but which are also affected by interference. They were saved several additional years of research effort by attending a recent U.S.-U.S.S.R. conference in the Soviet Union. Soviet experts shared their own concepts which were then used by the U.S. group to solve the problem. The Soviet techniques are now in general use by the U.S. group. This significant contribution to information theory may lead to development of improved communication systems. (U.S.-U.S.S.R.)

19. The understanding and exploitation of geothermal energy have recently become important subjects because of the world-wide energy crisis. Scientists of the Universities of Hawaii and Pisa, Italy, have recently discovered better ways to measure heat and pressure in subterranean molten rock (magma) formations. They have also developed a new seismograph for recording tremors generated by magma chambers. (U.S.-Italy)

20. A manual to help persons who must identify rusts and other diseases of such plants as coffee, beans, and tropical cereals is being produced by a Cornell University scientist in cooperation with colleagues in Brazil. The project has collected 500 samples for study and has described 3 genera and 10 species new to science. For the first time a rust that affects palm trees has been identified. Such findings become important as increasing use is made of tropical lands for cultivating crops. (SEED)

Dr. ATKINSON. I might turn to Dr. Nierenberg to comment further

Dr. NIERENBERG. Mr. Chairman, the principal comment I could make is that we agree completely with your point 4; it is stated very well and succinctly. I will spoil my comment by continuing and saying a little more. That is, it is a very important growing area. My opinion as a member of the Board is that we have reasonably good working relationships with the Department of State at the working level which is very important. I think the problem that persists is more with our own Board, I must say that has not until very recently been sufficiently involved with these matters.

The Board is and has been for a year and a half taking a much deeper interest in these problems; partly, and let us say, because of budgetry implications which are growing.

I am particularly struck by your choice of very important matters, those that affect health, agriculture, and nutrition, and then your mention of energy in your opening statement. Those, of course, are very important. We are particularly well equipped to help the Department of State and other agencies in the substantive parts of the programs.

These are the ones that I call, for lack of a better definition, rather political in nature.

There is another class, which is very agonizing right now, that is, having to do with freedom of research in the mid-oceans. That, of course, is related to the Law of the Sea negotiations. We have worked very closely with the Department of State in this area, too. It is an unhappy situation, as you well know.

There are other very important problems that are characterized with some naivete as nonpolitical that are coming more and more into international operations; for instance, global pollution problems such as those relating to the ozone layer. I did mention freedom for research in oceans and other related problems such as the weather problems and the climate problems. Climate is a global problem.

There is the Antarctic program and related programs. Again, the Foundation is in a peculiarly good position to be the substantive organ, so to speak, of the U.S. Government, working with the State Department and other agencies in these areas.

Above all, we must never forget the value of sceintific exchange programs in dealing with people and hoping to develop human understanding.

I would like to quote Prof. I. I. Rabi, who has been working in international programs for many years; that science is one of the most valuable bridges between people, and hence performs a valuable function in this regard.

To summarize, Mr. Chairman, we as a Board have been becoming more and more aware of the importance of these problems and working very hard to do exactly what you say.

Senator KENNEDY. I have a number of other areas, before yielding to Senator Chafee.

The problem that I have seen in the past—I do not know whether you care to comment on it or not—is that in too many instances, the NSF has had international programs and projects jammed down its throat. We suddenly wake up in the morning and find out that *X* President has agreed with the President of *Y* country in an area of scientific research without any consultation with you. Priorities seem to be established by other agencies rather than your own.

I quite frankly feel that NSF and the Board members are the best equipped to make those judgments. These matters ought to come through the initiation of the Board and the NSF staff rather than the other way around. We need to be sure that the State Department understands that and calls on you.

To the extent that we can be supportive in that area and work with you and remedy that situation, we will welcome the opportunity to do so.

Dr. ATKINSON. There is a great deal of interest in this matter. The Foundation has been in active contact with the State Department, with the Office of Science and Technology Policy, and the Federal Council will take up as a primary item on its agenda the issue of the coordination of our international science programs.

Senator KENNEDY. I want to have an opportunity later to talk about our young scientists and engineers and continuing education programs, and what is being done for minorities and women.

I will yield now to Senator Chafee.

Senator CHAFEE. I have some questions here which Senator Griffin had prepared for Dr. Creutz, and perhaps if you could give a rather brief answer to some specific questions, oddly enough dealing with Michigan, and if you will be good enough to submit these for the record, I think it will be very helpful.

Dr. CREUTZ. We will be pleased to do so, Senator.

[The response to Senator Griffin's questions follow:]

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Responses to Senator Griffin's Questions:

Question:

1. Are you familiar with the efforts being made by the University of Michigan to obtain funds from NSF to assist in building a Naval Architecture and Marine Engineering Center?

Answer:

1. Professor Ogilvie visited the Foundation on February 7 and discussed his ideas with me. Several of the Foundation senior staff were present as were the Acting Division Director of Engineering along with relevant program staff. The meeting was informative.

Question:

2. Do you believe that there is a national need for the kind of facilities proposed in the Feasibility Study submitted by Dr. Francis Ogilvie for research, development and education in support of the Marine industry and of Marine-related government agencies?

Answer:

2. During our meeting of February 7, Professor Ogilvie provided the Foundation with a detailed report concerning the question of need as well as the major features of such a center together with a suggestion for a management plan. The Foundation is presently digesting the contents of this report.

Question:

3. Do you believe that if such facilities were to be built that a synergistic approach -- combining research, development, and education programs -- would be most desireable?

Answer:

3. The Foundation is considering a feasibility proposal from Professor Ogilvie relating to the question of a Naval Architecture and Marine Engineering Center. The final results of such a study could provide a clue as to the relative merits of a synergistic approach vs. some other approach.

Question:

4. Do you consider the University's proposed plans as generally sound in formulation and/or estimated costs?

Answer:

4. We have not yet made an evaluation which would permit us to answer this question.

Question:

5. The University of Michigan is going to contribute a $2.5 million building to the proposed Marine Center. Do you feel that the remainder of this project's cost should be supported by Federal funds?

Answer:

5. The possibility of support by industry users of the facility should also be explored along with the exploration of possible federal support.

Question:

6. Would NSF sponsorship of the Marine Center help ensure that the Center would serve such Federal agencies as the Coast Guard, Navy, Maritime Administration and Corps of Engineers, as well as the Marine Industry?

Answer:

6. The Foundation's mission is to support basic research in science and engineering whereas the other agencies have roles distinctly different from NSF. It is not clear what effect NSF sponsorship would have on other agencies.

Question:

7. What is your opinion of the University of Michigan as a site for the Center?

Answer:

7. University of Michigan has a well established Naval Architecture and Marine Engineering program with a most competent and active staff. Thus it would be safe to assume that their interest in such a center would increase in the future; however, any detailed comments on our part would be premature.

Senator CHAFEE. I must say I was impressed by the way NSF works and the way you were able to give out your grants, and there seems to be so little—both public and professional criticism of what you do. There are very few agencies that seem to survive without a good deal of criticism.

I don't know, but there don't seem to be many disgruntled universities who don't get their share, who don't come back and attack you for favoritism.

So I am impressed. Maybe you do spread it around generally enough so that everybody gets something, although I'm sure that's not part of your modus operandi. Some 2,000 do get in on it, do they, the share?

Dr. ATKINSON. The real success, Senator, of our program, is that we rely heavily on the scientific community to make these decisions. We have each year more than 30,000 scientists contributing without any payment to the peer review process. It is that peer review process and their evaluations that are the basis for our decisionmaking.

It's a very public matter, As soon as a grant is made, the scientific community knows that the grant has been made, so there is a public monitoring of it. In that sense it's a very open—and I think very effective—process.

Senator CHAFEE. Well, certainly, I didn't mean to be facetious, because I think it is extraordinary. I have had some connection with a university, and when they lose out they never cry "foul," but everybody seems to be satisfied that it's been a fair shake, and the way you do it is extraordinary.

So I would like to congratulate you on that.

Dr. ATKINSON. Senator, I'm going to inject yet another remark. I have had reason to look carefully at Brown University in the last year; in part because my daughter is a student there. Brown University has done remarkably well in the NSF grant competition. If one compares the number of Ph.D.'s in the sciences with the number of grant dollars received, Brown University is about fourth in the country in terms of funding per science Ph.D. That's a testimonial to its high quality facility which seems to be very competitive in seeking research support.

Senator CHAFEE. Well, that merely reinforces what I thought of your good judgment.

But I would like to say this. Maybe Senator Kennedy, in his question dealing with the foreign grants—I'm not sure whether it was Dr. Nierenberg—but word was mentioned of nutrition, and I just am extremely interested in keeping people healthy as well as curing them when they're ill, and I just think the more this country can spend of its energy and effort and talent toward this whole area of preventive medicine is a tremendously valued investment.

And as I look over your areas, I know obviously health is—and that's very basic research, and percentagewise, I suppose, not a very large part of your endeavors, is it, the way I look at it?

Dr. ATKINSON. Biological sciences count for about $100 million of our budget. Basic research both in human biology and plant biology is a very important component of the Foundation's activities.

In the reorganization of the Foundation, a special Directorate was formed to represent biological areas. The fact that we have one of our

Assistant Directors responsible for that area—Dr. Clark—on my right here, is an indication of the importance the Board and the Foundation place on the importance of a strong program in basic research in the biological sciences at the National Science Foundation.

Senator CHAFEE. Well, I just wanted to indicate that that is an area that I am, really, as one member of this subcommittee, at any rate, very interested in—the role, the whole effort to keep our people healthy, and I know it involves a good deal of self-discipline on the individual's part, and it is something that cannot be dictated from on high, and that research won't necessarily produce the answer.

I think probably we now know many of the answers, but people won't respect them. However, I think that the more attention we can draw, perhaps through research, to the eating habits of our people, what they can do to keep themselves fit, is an excellent investment.

Thank you very much, Mr. Chairman.

Senator KENNEDY. I want to join Senator Chafee in his comments. There is a great promise in biological research and our committee is going to be looking into the biomedical research being done at NIH. For instance, we know there has been movement and shift in some of the diseases which affect the developing world. The work that can be done in the National Institutes of Health can be very, very profound in terms of the international health implications.

And AID has a component in international health, which used to be absolutely superb, and over the period of recent years, it's had less priority due to budget restrictions.

But if you visit the Cholera Center in Dacca, you see the work that that has done in saving lives, and the contribution that has made in that part of the world. For "chicken feed" in dollars, a lot of good has been done for humanity. The interests of the United States have been served as well. It's really enormously impressive.

And there are opportunities like this across the landscape. You find what many of these developing countries have done in delivering health care, and the emphasis that they have placed on preventive health care. It is extraordinary, in many many instances.

There are great contrasts in delivery of health care, for example, in North and South Vietnam—enormous contrasts. In many instances, the techniques for the delivery in many third world countries, in reaching remote areas, distant populations, is very sophisticated.

There are important implications in terms of health, in terms of the finest goals of our own society. What we can learn about it, is profound. It's an area that we on this committee are very much interested in. We welcome, obviously, Senator Chafee's deep interest in this. It moves on a little bit beyond your direct responsibility, but it's one that I think we're underlining and that we hope will be a matter of interest and concern to the Board.

Dr. ATKINSON. Senator Kennedy, your statement that it's a two-way street, needs to be emphasized. My experience in the year and a half that I've been at the Foundation is that the United States has gained a great deal from these programs, and in turn I think we've done a very important service.

Senator KENNEDY. If you look at how the budget of the World Health Organization has been structured in recent times, you see a very major redirection into these disease research in third world countries. We have enormous opportunities and there are profound implications for the people of the world as well as for our national interests and influence.

In another area, could we talk about the oversight of grant recipients. Cases have come up recently in the policy research program of situations where grant recipients were given so little guidance that NSF lost control of some of their activities.

In some of the basic research areas, I'm told, oversight is so rigorous and funds are so scarce that scientists feel severely constrained.

Now, what can be done to even out this situation and insure monitoring of researchers and assurance that scarce research funds are used effectively.

Dr. ATKINSON. That's a complicated question, Senator Kennedy, and I'd like to add some remarks for the record.

We are in a situation where, with the shortage of funds, we are turning down a higher percentage of grants than ever; these are proposals that often are of high quality.

The issue of the peer review process and oversight is one that has been under careful analysis by the Foundation, and by the National Science Board. We have made a number of changes in our procedures and policies that have been widely reviewed by the scientific community and generally accepted as important steps forward.

We have not completed that process. There are still some additional factors to be considered, but the Board's views are that within the next 3 to 6 months, we will pretty well have satisfied our concerns in this area.

On the other hand, the whole area of policy research is somewhat special. There is no question that granting policies that cover other types of research also apply in the policy research area, but it is an area that is going to require special attention. I think it's fair to say that the primary item now on the National Science Board agenda is to review our whole program of policy research and try to determine whether our policies and procedures are adequate.

Senator KENNEDY. Well, up to date you have only awarded, as I understand, some $200,000 in policy research out of your $4 million budget for policy research; is that right?

And now we are halfway through the fiscal year. The question, I suppose, is whether you can award the other $3.8 million in the next 6 months effectively, or whether some of that ought to be carried on over.

Dr. ATKINSON. I think the answer is "Yes," we can. Policy research is really in three separate directorates of the Foundation: in STIA: policy research very much oriented at science issues; in the RANN Directorate, a broad range of policy research concerning national needs; and in a certain sense, in the Social Science Division of the BBS Directorate, where there are some additional efforts.

But I think your remarks are primarily targeted at our program called Policy Research and Analysis in the STIA Directorate.

Senator KENNEDY. That's right.

Dr. ATKINSON. I think it's fair to say that we don't anticipate problems in expending our funds in that directorate.

Senator KENNEDY. I'm sure you can expend them.

Dr. ATKINSON. Dr. Granger?

Dr. GRANGER. I just had one comment, that the level of grant commitment activity in policy research and analysis in the STIA Directorate is pretty much on our commitment plan established at the beginning of the year.

We deliberately set out to hold down the grants in the early part of the fiscal year with the expectation that the Office of Science and Technology would come on line and begin to want specific studies, in particular areas, and that these would be funded in the latter part of the fiscal year.

Senator KENNEDY. Next let's discuss the young scientists and engineers, and what the NSF has done to provide opportunities for young scientists and engineers to compete for research grants, to obtain fellowships.

I mentioned this rather briefly in my opening comments, but I wonder if you can tell us a little bit about what you're doing, what programs are provided in the pending budget to assist the young scientists?

Dr. ATKINSON. Senator Kennedy, I'm going to turn to Dr. Averch to comment on this. I do think there's an issue raised that's a very broad issue. There are specific things that NSF can do now. But what's equally important is planning for the longer range future.

As you well know, there is going to be something like a 20-percent reduction in the number of university-age students in the next 15 years. There is going to have to be a significant decrease in faculty if universities are to continue to operate in the mode that they are currently operating in.

What we have is a situation where, over the next 15 years, we have relatively few expected retirements at the universities, a severe drop in the enrollments, and if something is not done, there are going to be very few openings for young scientists.

The Foundation has a number of studies underway, trying to anticipate the problem and anticipate longer term solutions. By that I mean solutions that would open up positions at universities to younger scientists and would guarantee a steadier flow of young scientists into the university community. I assure you that that is a primary concern for us.

I think, though, what you're speaking to now is a view of our particular programs, and let me turn to Dr. Averch on that.

Dr. AVERCH. Senator Kennedy, I will just comment on a few of the programs in the Directorate for Science Education for young scientists.

You will notice that we have increased the postdoctoral fellowship program from $1.1 million to $2.3 million. That should essentially double the number of postdoctorals. I think that is quite important in maintaining young scientists and research assistants, and we're going to need them.

The research initiation and support program, which is an institutional program, is budgeted at $4.5 million. At last count there were about 1,600 young scientists being supported in that program. As Dr. Atkinson noted, many of the opportunities for young scientists will lie in industry rather than the academic sector, so we are prepared to fund new curriculum materials, and to assist the revision of graduate programs.

So I would estimate roughly there are $7 to $8 million total for young scientists.

Dr. HACKERMAN. Senator Kennedy, I would like to interject, if you do not mind.

At the next regional forum the National Science Board will hold on April 12, the board made the determination that, aside from getting the views of regional concern, we would ask the public members who appeared at those forums about three things that concern us.

One of them is the support of young scientists. I have no idea what kind of response we will get, if any, but the question is uppermost in our minds, constantly.

Senator KENNEDY. Could you give us a note after you have your meeting, as to what recommendations they make?

Dr. HACKERMAN. Surely; certainly can.

Senator KENNEDY. I think that might be helpful to us, because we are very interested and we want to work with you. Every one of us who talks to the deans of our universities hears the same story, and it's a question of how we can best deal with it.

Let me also ask what, if anything, we should be doing in relationship with industry, to continue to provide opportunities for scientists and engineers for careers in science and research.

It's a very complex and involved issue, but I think you know what the problem is, and we are hearing what the problem is, and we would like to work with you and find out how best to deal with it.

One of the other areas that I've had a long interest in relates to continuing education opportunities for scientists and researchers. You know very well that the scientist is trained in one particular aspect of science and after 10 or 15 years, the knowledge base can change dramatically.

I have nephews up at Harvard—in the humanities—and they're taking the same courses I took 20-odd years ago, and from some of the same professors.

Dr. HACKERMAN. The tests are different.

Senator KENNEDY. They sometimes say the answers are different today. The questions are the same, but the answers are different.

But obviously, it is different in the area of science and technology. We saw between 5 and 7 years ago, in our region of the country, where—with reductions in defense and space-related research development—numbers of scientists and researchers who were put out of work. If they had been able to upgrade their skills with continuing education, their opportunities for employment would obviously have been increased with a multiplier effect in creating additional jobs for others in the society.

We asked you to do a $200,000 study last year, leading to a substantial program in continuing education this year.

Can you tell us what's happended to that study? Why isn't that program included in the budget?

Dr. AVERCH. Well, Senator Kennedy, $500,000 was authorized, but we did not require that much. We are submitting today an interim report on continuing education, and proposing that we go on and conduct some more studies with what was authorized.

I think you are quite correct, though, that the estimates on the "half-life" as we call it, of our stock of scientic knowledge, has been falling.

One estimate says that the knowledge of the class of 1935 in chemical engineering was obsolete in 20 years. Now it's obsolete in 5 years. So the class of 1970 may now be obsolete. There isn't any doubt that both in the academic sector, and possibly in the industrial sector, there is a major problem, what we might call professional obsolescence.

And I would argue that industry perhaps had been more sensitive to that question than the academic sector. We just have to look hard at professional redevelopment and career redirection.

So we discuss some options for the academic section in our March 1 report.

Professional obsolescence in the industrial sector is also quite important, and last years' interviews with industrial leaders that the National Science Board conducted for its report suggest that we want to look a lot harder at the obsolescence question in industry. The consensus of the literature and of the public input that we got is that on that question, we really need to do a lot more research.

Industry does spend a lot of money on continuing education, on-the-job-training, and it was suggested that we try to untangle organizational factors and the personal factors, and just see where the Federal Government might appropriately take action.

There is another aspect of the question, though, and that relates to continuing education and unemployment. This is a different kind of question.

Unemployment rates among scientists and engineers, as you know, go up and down with the business cycle. There is a question whether or not, in the absence of sufficient demand for the products of the "knowledge sector," if I can call it that, that kind of continuing education program will do much good.

So one solution is to have adequate monetary and fiscal policies so that we maintain aggregate demand. Occasionally, you get into a so-called structural problem, where the skills that our scientists have just do not match needs, and that's where you want to look at continuing education and at other alternatives.

I think, again, our report suggests that it's an area we want to look hard at. There are two phenomena to which I would like to call your attention.

One is that many of the programs that we had in the 1970's perhaps were not designed to well and did not work too well. The direct programs for putting aerospace workers back on the job did not work as well as the information and counseling programs for aerospace workers, so we are trying in our studies to strike some balance of what does not work and what the costs are.

The other point in continuing education is that many of those who need it least use it most. That is, you get the very young, very able, very active, taking part in a continuing education program. Other countries have had the same kind of problems.

In Germany and France, where they're very active on that front, it has been the young and capable workers and scientists who have taken part in that.

So as a net result, we are proposing very active programs in the academic sector, and we are proposing to go on and use some of our moneys for somewhat more rigorous and deeper studies on the industrial side.

Senator KENNEDY. Well, I would hope you would move on this. This is a real problem. We passed S. 32 in the Senate about 1971, with all its imperfections, to try and deal with this problem. Continuing education for scientists and engineers is still needed and it is still a problem.

Even with the unemployment rate for scientists down, to about 1 percent—it's still considerably higher—about 400 percent higher—for women than it is for men. We thought last year when we had the study, that you would at least come up with a program that might be examined, studied, and evaluated to reach some of the problems that you mentioned.

And now we've seen it slip, effectively for another year.

Dr. AVERCH. Well, we haven't slipped, Senator Kennedy. I think the net result of all the public meetings we have had, and our own analysis, suggest that we do need to conduct some experiments between the universities and industries in joint ventures in continuing education. Those have been suggested, and we are proposing to go ahead this year with these kinds of experiments.

Senator KENNEDY. Well, you're going to go ahead this year on some of them; is that right? Up to how much?

Dr. AVERCH. Well, we have $1.2 million total allocated in fiscal year 1977.

Senator KENNEDY. And that is not just for studies?

Dr. AVERCH. The $1.2 million is for development of experimental curriculums. In our new guidelines for this program we have singled out continuing education as an area of experimentation, perhaps with industry.

I think it's true that the academic sector these days is just paying a lot more attention to the continuing education mission, and that it will require some assistance in designing programs and in making contact with industry. We are proposing—not just studies this year, but active programs.

Senator KENNEDY. Well, we will follow that closely with you; it's been an important matter of concern.

Now, I understand that the Science Board is concerned that the million dollars authorized for minority graduate centers is not adequate to meet the extent of the need, and yet there are no additional funds for the program in the pending budget. The Board's own 5-year plan provides virtually no increase for the future.

Now, how do we reconcile that with what the Board has stated about the importance of dealing with that public policy issue and your budget request?

Dr. HACKERMAN. Well, one thing we're doing is—if you'll let me tell you about the second of the items that the Board is asking the views of the public on—views on women and minorities——

Senator KENNEDY. I was going to come to that.

Dr. HACKERMAN. The questions of how best to do this and whether you can induce this kind of activity effectively have really not been settled.

We know that money alone cannot do it; you must get interest and involve viable individuals in it. The problem is that we want more than we know how to do at this time.

So we are asking for outside advice, and we are also, among ourselves, trying to find better ways to get involved with it.

Senator KENNEDY. Well, what have been some of the suggestions that have been made to you from various kinds of women's groups and others that you have perhaps discounted or felt were not effective?

Have you received suggestions to date? Tell us what they have been. Have you met with these groups?

Dr. HACKERMAN. No; we have not.

Senator KENNEDY. Well, who are you getting your advice from, then?

Dr. HACKERMAN. We have an internal committee.

Senator KENNEDY. Made up of who? How many women on that?

Dr. HACKERMAN. Members of the Board.

Senator KENNEDY. How many women on that?

Dr. HACKERMAN. The Chairman is a woman, and there are three additional members of the Board.

Dr. AVERCH. Senator Kennedy, I might add that I myself am pleased to have increased the number of women on the Advisory Committee for Science Education to where they are close to half the representation. They do discuss the programs for women.

Also, as you know, these days it is a standing procedure for any program in education to publish draft guidelines and get very wide comment, so the three activities we have for this year have been, in a sense, endorsed by the public and by women in the public.

As you have pointed out, the reentry opportunities for women who get out of the scientific labor force for a while are formidable. To overcome this barrier we are funding career counseling on campuses and this year, for the first time, visiting women scientists to go into the high schools, bring their graduate students with them, and to talk about the opportunities they have and about the difficulties they encounter.

I think we are, again, looking for innovative and effective experiments, both in our research guidelines and in our development guidelines. This is an area where we want work done.

Senator KENNEDY. We're going to follow this very closely, because we have a number of suggestions and recommendations that have been made to me by various women's groups—about the importance of reaching out to women while they are in high school and in the immediate postcollege period. The suggestions that are made seem very good. I would hope that as we follow and oversee this issue, you will make contact with various kinds of scientific groups, women's groups, and others. We need to know what effort has been made, both in the areas of minorities and women. We need to find out what their recommendations were, which were considered positively and which were rejected, and the reasons why these were rejected.

I don't think anyone is suggesting that this is an easy problem to solve. But unless we are really going to come to grips with it, we are not going to see much progress made.

Dr. ATKINSON. Senator Kennedy, you have hit upon a whole series of issues that fall within the Science Education Directorate—women and minorities, the handicapped in science, science for citizens, public understanding, and the like. I assure you that these issues are getting attention at all levels of the Foundation, including the National Science Board.

I can say that in the planning for the 1979 budget, the Science Education Directorate has received a great deal of attention. We are talking there about a very substantial increase in the Science Education Directorate to deal with some of the issues that you have raised this morning.

Senator KENNEDY. Well, that will be, I think, very well received. It certainly will be by myself and I think by other Members, too.

Let me also put in a word about this curriculum development program, I think we can mention it, now that the bombs have gone off. I am concerned that it has been effectively brought to a virtual halt.

Would you venture any kind of comment as to where it might go in the future and what steps might be taken to try and bring the curriculum program back?

Dr. ATKINSON. Senator Kennedy, again this is a complicated question, but let me add a few remarks.

In the 1960's, when the National Science Foundation was requested to develop a science curriculum, it targeted that curriculum at outstanding students who could be drawn into the sciences. There is no question that the Foundation has had a brilliant record in this regard.

When one looks at the drop in test grades for students across this country, there is a small core of students where test scores have consistently gone up. It is this small group of students who are being drawn into science, and in that sense the National Science Foundation has done a very good job.

But there has been a very negative consequence to all this, and the negative consequence, in my judgment, is that science curriculums, as they have evolved, have become too tough for the high school level. There are too many students at the high school level who have talent, who have interest. But the curriculums have been oriented to the NSF view of things—namely, of very, very difficult curriculum, with a science-education group which is very organized for teaching it. The end result has been that although we have provided fantastic education for those few students who can take advantage of it, there are many other students who are being ignored. In my judgment, this is one of the important areas of consideration: the development of science curriculums that will hit more of a middle ground that is, those students who fall, say between the 40 and 80 percentile. I think there is no end of students who have been cut out from further work in science at the college level because they were not quite motivated enough, or the course being taught in their high school—the calculus, or physics, or whatever—was at too high a level.

My own judgment is that there exists an urgent national need to improve science curriculums in the high schools, science curriculums aimed more at that middle segment of students. I think that is an important effort for the country to turn to. I believe the National Science Foundation would have a very special role in that effort.

So my response to your question is that I do not think we have finished our job in science curriculum; there is a more important job to be done in the next 10-year period than has been done in the last 15 years.

Senator KENNEDY. I would hope you would continue in that. There is a lot of reevaluation going on, and review, and the rest, but I would that you would move ahead in this area.

I think it is just terribly important. I think it will reach some of our other issues, in terms of interesting people in the creativity of science and in careers in science.

I think what we are seeing is that an awful lot of young people are confused about where they may be in terms of their future, and future careers. If they miss one of those science courses at an early time, they never can get back into it, to catch up and to rethink career choices.

And if there is a matter, I think, that continues their interest through school, it may be a science-related course that is interesting and stimulating. I think there are excellent opportunities to attract young people into careers in science and bringing them on into discussions. I think it is very, very possible.

So I would hope that you would stay after this issue and see what can be done. I think it's terribly important.

Excused me. Dr. Averch?

Dr. AVERCH. Senator Kennedy, I would just note that we have every intention of staying in precollege curriculum development. We are coming back up from the $1.4 million this year to about $2.4 million for the precollege curriculum in 1978.

We are doing that in a new fashion and following the recommendations made by the Congress——

Senator KENNEDY. What had it been running? What was it running?

Dr. AVERCH. The amount for precollege curriculum development has been as high as $13 million.

Senator KENNEDY. Just a couple of final areas.

One of them concerns the 300,000 scientists and engineers working in industrial laboratories. These industrial laboratories are providing important opportunities for an increasing number of graduates from our universities.

Industrial laboratories have a unique capability in the area of technology transfer; the panel which advised the NSF in this area recommended that NSF allow researchers in industry to compete on an equal basis with other researchers for research funds.

Can you tell us why that recommendation was not included in the final report? What has been the reaction within the Foundation? It obviously raises some tough questions. We are mindful of what it would mean.

For example, in the health area, you know, the private research is small but very important in terms of what it means in the eventual spinoff to drug companies and all the rest.

We are going to get into that issue. There is a great deal more that I have to know about it.

What is your reaction?

Dr. HACKERMAN. As a nonoperating member, I have always been under the impression that basic research proposals submitted by scientists in industry should be given the same attention as those that come from other institutions. A decision would be made primarily on the basis of the quality of proposals, the individual who proposed to do it, and the facilities he has.

The difficulties are those that you have already mentioned: namely, the problems as they affect the business. Nonetheless, this is a matter of concern, and you may not be surprised to learn that our third area of interest at the next NSB Regional Forum will be alternate sources producing basic research.

We think we have an answer, but we want to find out whether there are other possibilities that we have to consider.

Senator KENNEDY. Well, as I understand, the present NSF policy states that it is only in exceptional cases that unsolicited proposals for basic research will be considered from industrial organizations.

Dr. HACKERMAN. I have taken that to mean that, if the proposal is satisfactory, the exceptional problems are those which relate to the fact that it is in the business-industrial laboratory.

That is my own view of it. I would be glad to hear whether that is right or wrong; but I personally do not think it has to be exceptional in terms of the quality of the proposal.

Senator KENNEDY. No; it should meet the same criteria applied to proposals from academic researchers. What percentage of basic research funded by NSF goes to research done in industrial laboratories?

Dr. HACKERMAN. It's very small. I will check on it for you.

[The information referred to follows:]

About three tenths of one percent or $2 million of the $589.3 million budget for the Foundation's three principal Basic Research Directorates: Mathematical and Physical Sciences, and Engineering, Biological, Behavioral, and Social Sciences; and Astronomical, Atmospheric, Earth, and Ocean Sciences; goes to researchers in industrial firms. Additionally, portions of a number of RANN research projects involve basic research studies. About 1½ percent of the RANN program or $1.2 million is considered to be basic research which is conducted by private firms. The total basic research conducted by industry under NSF support in the major Basic Research Directorates and RANN programs totals $3.2 million. This represents approxmately five tenths of one percent of the $667.3 million budgeted for the three Basic Research Directorates and RANN program in FY 1978.

Dr. ATKINSON. Senator Kennedy, though, I want to comment on this report, which you are well aware of, on the relationships with industry. The NSF industry report is really just a first step in the Foundation's full review of relationships between universities, industries, and the Foundation, in support of both basic research and applied research.

There are a number of recommendations in that report that the Board has approved, that are really going to have far-reaching consequences—the possibilities of joint proposals from scientists at universities and industry for joint effort and the like.

I think that we need time to judge the future. There are lots of different trends at work; the problems our universities are having, the whole issue of young scientists—there are so many trends at work that it's important to move with speed, but also with knowledge in this area, and I think many of the recommendations here are really quite farsighted and are going to be important developments.

The whole issue of whether we should try to open up our whole basic research effort to wide involvement on the part of industry is a real one. I think the Board has not favored this and has not because it's gotten strong advice from all segments of the scientific community—both the industrial segment and the university segment—that that would be an unwise decision at this point in time.

But we are not fixed in that view. It may well be that in 3 or 4 years from now, attitudes might change significantly.

Senator KENNEDY. Well, that's something we need to give some thought to. I can understand that the academic side of the community wants to keep what they've got.

The question is our responsibility in terms of the country's interests, which are obviously yours, too. There is a very clear trend of some of the youngest and brightest scientists and engineers going into industry. It is true in my part of the country, and I'm sure it is in other parts of the country. I am as sensitive as anyone about giveaways to private industry and what that would mean, and all of the implications.

I don't minimize the complexities of the problems. But if we wait until the academic-scientific community comes around to the point and says, "All right, some work over there in the industrial sector is going to be OK," we are going to wait more than 3 or 4 years.

Dr. HACKERMAN. That is really not quite the case. Industrial scientists are involved in our review systems, for example, and the fact is that industrial scientists are not very interested in getting these very basic research programs into their laboratories.

The reason is very clear. It has nothing to do with patents or anything else. It has to do with a very large time commitment. The systems that you need and the kind of research you are talking about span years. Not many industrial laboratories are willing to put their people aside for long periods of time so they can pursue one of these things.

Because of that, they are very apt to turn down the request of the searcher, to send the proposal outside for consideration.

I am involved with industrial research laboratories, and I know what that leads to.

Senator KENNEDY. Well, I understand that the large companies and corporations, might not be very interested, and I understand that the smaller ones may not have the necessary capacity.

But we have a lot of medium-sized firms up our way, who are definitely interested. I'm reminded by staff that we'll have some testimony on this, which I'll value, and we can expect to learn a good deal more on Thursday.

Dr. NIERENBERG. I agree with Dr. Hackerman very much.

In fact, I think that he has identified an important problem. In business, management restricts the freedom of operation of its research.

Even so I never have seen any real difference in attitude between industrial and academic people who are interested in basic research. They are essentially the same people, in the same mold, and the problems are more as Dr. Hackerman outlines than anything else.

Senator KENNEDY. Well, we will bring these up on Thursday and have a good session on it.

We want to welcome Senator Javits, who's a very interested and active member of our committee.

We've had a good session here, Senator Javits. We have covered a number of different areas; we talked about science education, about young scientists and engineers, about continuing education for scientists and engineers, about minorities and the programs for women, about the oversight of grant recipients.

The international programs have been talked about, the makeup of the Board itself, some of the ethical programs that are being developed now.

We also got into applied research programs.

We have had good responses, I think, to these questions, and I think this was a good meeting.

We have welcomed having Senator Chafee here. Is there anything that you would like to bring up?

Senator JAVITS. Thank you, Mr. Chairman. We had a long executive committee meeting in the Foreign Relations Committee this morning.

Thank you, ladies and gentlemen, very much.

Senator KENNEDY. Senator Pell, who is also a member of the subcommittee, has some questions. I will submit those and if you will respond, we will make them a part of the record.

[The response to Senator Pell's questions follows:]

NATIONAL SCIENCE FOUNDATION
WASHINGTON D.C. 20550

nsf

OFFICE OF THE DIRECTOR

April 4, 1977

Honorable Claiborne Pell
United States Senate
Washington, D. C. 20510

Dear Senator Pell:

I apologize for the delay in answering your questions on Oceanographic Research Facilities and Support and NSF funded coal research. The program responses to your questions are attached.

The Foundation's long range program plans provide for ship construction and for equipment and instrumentation needed to conduct an effective and efficient oceanographic research activity.

Good progress has been made in upgrading the academic research fleet since 1970. But there are continuing high priority requirements for oceanographic research ships, instrumentation, and equipment. Based on preliminary findings in a current study being done by the University National Laboratory Systems (UNOLS), coastal research vessels and ice strengthened research ships suitable for polar work are among the highest priority needs over the next several years.

The Foundation is considering plans for the construction of a coastal research vessel and an ice strengthened ship in FY 1979 and various other ship construction and replacement alternatives are being examined for the early 1980's.

Please be assured that we are making every effort to provide modern research ships and instruments for the nation's oceanographic research effort. Today, there are only five ships operating in the fleet that are outdated and we hope to correct this situation by the early 1980's.

I know you appreciate the fast pace of technological improvements in the oceanographic research area and the need for careful planning in making commitments for ships and other facilities that carry with them a long-term sustaining support obligation. I believe the Foundation's FY 1978 budget request for oceanographic facilities and equipment addresses the most urgent requirements and provides for a continuing effective program of oceanographic research.

87-769 O - 77 - 8

The question on coal research deals with an NSF project being conducted by Boston College entitled "The Pennsylvania Coal-Bearing Strata of the Narragansett Basin". NSF has no plans to continue funding this project beyond the current commitment. Should the project continue beyond that point, funds would probably be sought from the Energy Research and Development Administration. The Foundation will assist Boston College and the regional supporting agencies in preparing for the transfer of funding responsibility

I greatly appreciate your continuing interest in the Foundation's program and your efforts in insuring that the United States has a strong program of oceanographic research. I trust that the enclosed information will prove helpful.

Sincerely yours,

E. Creutz
Acting Director

Attachments:
1) Responses to Questions
2) List of Academic Fleet

Attachment No. 1

Question 1: Please provide a status report on the Foundation's study of oceanographic research vessel construction needs. Is the study completed? If not, when will the study be completed? What long range plan exists for meeting national needs for oceanographic vessels?

Answer: The Foundation's Office for Oceanographic Facilities and support continuously monitors the condition of the academic fleet and maintains updated target plans for needed upgrading and replacement. This fleet assessment is done in coordination with the Navy--the other principal source of support for construction and operation of the academic fleet.

UNOLS provides a major source of community input to this continuous planning process, and it is this organization which has under preparation a specific long-range study of scientific requirements for vessel construction. The preliminary report from that study emphasizes the critical need for both replacement and additional new construction of coastal vessels ranging in size from 85 ft. to 150 ft. The report also targets the need for an arctic research vessel. As a follow-on to this study,, UNOLS initiated and NSF funded six conceptual design efforts during FY 1976 for coastal ships and ice-strengthened vessels for use in polar areas. These studies are nearing completion and will be evaluated within the next few months.

Construction of ships in these categories is addressed in the Foundation's long-range plans, as is the possibility of further construction of medium-sized ships of the Columbus Iselin or Oceanus type. Ship acquisition for the academic fleet is not, however, carried out exclusively by the Foundation. Of the ten new vessels added to the UNOLS fleet during the 1970's, four were acquired entirely from State and private sources, two were built by the Navy, and four were funded by the Foundation. Long range planning for the fleet as a whole is, accordingly, an activity for the larger marine research community.

NSF pursues its role in this process with the academic institutions via UNOLS; and with other Federal agencies, through the NSF-Navy coordinating panels and the various other interagency bodies concerned with the use and development of the academic fleet.

Question 2: No funds have been requested for oceanographic research vessel construction for Fiscal Year 1977 or for Fiscal Year 1978. When does the Foundation anticipate reactivating the ship construction program by requesting funds?

Answer: The Foundation's request to OMB for high priority add-ons included funds for research ship construction in FY 1978. The base budget for oceanography is directed toward maintaining research program and related ship operations support. We expect to examine the relative priorities very closely in development of the FY 1979 budget submission. For FY 1978, however, it was our considered judgment that the need to sustain research and researchers and to upgrade existing ships (see question 3, below) enjoys higher priority than new construction efforts.

The Foundation's internal long-range plans--prepared at both a base and an opportunity level--have included vessel construction at the opportunity level for all recent years and through the out-years (to FY 1983) of our current 5-year plan. Thus, vessel construction will continue to be assessed annually in the NSF budget process during which our long-range plans are translated into Congressional budget requests.

Question 3: Construction and operation of an oceanographic research vessel constitutes a major investment of NSF funds. Accordingly, it is important that the vessels be used to maximum efficiency. (a) Is lack of modern equipment on existing research vessels a problem in achieving maximum use of these research platforms? (b) Have adequate funds been requested to meet the priority equipment needs for the most efficient use of research vessels? (c) What is the ratio of equipment funds requested by ship operators to funds available and granted? (d) Would additional equipment funds, beyond those requested, produce a substantial increase in the productivity of the research vessels?

Answer: (a) & (b) Providing adequate modern research instruments for shipboard operations is a continuing problem and one that is recognized by the Foundation's FY 1978 budget. An amount of $1.3 million is included in the Oceanographic Facilities and Support budget for instrumentation and equipment. This is about 30 percent more than the amount included for this purpose in the FY 1977 program. The amount for shipboard instrumentation is sufficient to permit effective operations.

The basic priority for achieving a high level of utilization of research vessels is the maintenance of the ships in safe and efficient operating condition. Thus each year a substantial portion of our oceanographic equipment funds must be invested in such basic requirements as generators, hull and structural improvements, winches, cranes, auxiliary machinery, anti-pollution systems, and communication systems. There is also a growing demand for new and more highly sophisticated shipboard systems directly related to the conduct of research at sea.

(c) For the past five years (FY 1973-1977), the ratio of equipment funds requested by ship operators to funds granted has been, on an average, 3.1.

(d) The rate of upgrading equipment could, of course, be accelerated. However, in some areas of instrumentation the state of the art changes so rapidly that it is not feasible to keep pace with every advancement made. In those areas that do not change rapidly, improvements are being made on a year-by-year basis with present funding levels, and those items that are not critical are postponed until the following year. Increases for instrumentation would probably increase productivity on some research.

Question 4: As you know, the Senate Subcommittee on Health and Scientific Research is considering a two-year authorization of appropriations for the Foundation. Do you foresee any substantial changes in Oceanographic project support, International Decade of Ocean Exploration, or Oceanographic Facilities and Support that would require adjustments in the authorization level for those activities for Fiscal Year 1979 from the requested levels for Fiscal Year 1978?

Answer: As noted in the answer to question 2 above, the Foundation requested additional ship construction funds as a high priority add-on in its FY 1978 budget request to OMB. Priorities for FY 1979 are currently being considered by the NSF Director and the National Science Board. No substantial changes in FY 1979 are included in the planning level figures being considered. However, add-ons above the planning figures have been proposed that could substantially increase each category mentioned in this question. It is, therefore, not possible to determine as yet whether or not unusually large increases will be requested for FY 1979.

Question 5: The National Science Foundation has participated in the funding of basic exploration of coal resources in Southeastern New England. What are the prospects for continued NSF funding of this effort?

Answer: The project referred to is "The Pennsylvania Coal-Bearing Strata of the Narragansett Basin" initially supported for $226,800 in February 1976. The National Science Foundation's grantee in the project is Boston College, whose Weston Observatory manages the geological research and drilling operations. NSF funds are used in support of the research, while Massachusetts Science and Technology Foundation and other public and private institutions in New England have supported the exploration drilling required to define the resource.

The Boston College grant was one of the last new starts by NSF in its energy resource programs. Since the research in this vital project should establish more fully the extent of the coal resource before transfer to a mission agency can be effected, NSF has awarded $109,300 for an additional six months of research support.

We are unable to support the coal resource project in the Narragansett Basin beyond the total current commitment of $336,100. However, our Resources program staff will actively assist Boston College and the regional supporting agencies in preparing for transfer of funding responsibility to appropriate Federal mission agencies.

For your information, we are attaching a copy of an interim report describing the progress of this project during its first eleven months.

OFS,1/77, for 1978 budget
& FY 1979 planning
Attachment No. 2

Academic Fleet Status

Total No. of Ships: 28+1 under construction Total no. of operators: 15

Open ocean: over 200', LOA

Knorr, 245', Woods Hole, 1970, Navy
Melville, 245', Scripps, 1969, Navy
Atlantis II, 210', Woods Hole, 1963
Washington, 209', Scripps, 1965, Navy
Thompson, 209', Washington, 1965, Navy
Conrad, 208', Lamont-Doherty, 1962, Navy
Gilliss, 208', Miami, 1962, Navy

Intermediate: 150-199' LOA

Vema, 197', Lamont Doherty, 1923
Oceanus, 177', Woods Hole, 1975, NSF
Wecoma, 177', Oregon State, 1975, NSF
Endeavor, 177', Rhode Island, 1976, NSF
Gyre, 174', Texas A&M, 1973, Navy
Moana Wave, 174', Hawaii, 1973, Navy
Iselin, 170', Miami, 1971
unnamed, ca. 170', Scripps, (under construction est. 1978)
Kana Keoki, 156', Hawaii, 1967

Shelf and Coastal: Below 149' LOA

Alpha Helix, 133', Scripps, 1965
Eastward, 118', Duke, 1964
Velero IV, 110', Southern California, 1948
Warfield, 106', Johns Hopkins, 1967
E.B. Scripps, 95', Scripps, 1965
Acona, 85', Alaska, 1961, NSF
Cayuse, 80', Oregon State, 1968
Longhorn, 80', Texas, 1970
Blue Fin, 72', Skidaway, 1972
Hoh, 65', Washington, 1943, Navy
Onar, 65', Washington, 1954, Navy
Maury, 65', Johns Hopkins, 1950
Calanus, 64, Miami, 1970

Distributions

(Note: all figures include unnamed Scripps Ship under Construction)

By-Region	By Age
NE Atlantic - 6	New - 0-10 years - 15
SE Atlantic & Gulf - 9	Middle - 11-20 years - 9
Pacific NW & Alaska - 6	Old - over 20 - 5
Pacific SW & Hawaii - 8	

By Ownership

Navy - 10
NSF - 4
Private/State - 15

By Class/Function

Open Ocean - 7
Intermediate - 9
Large Coastal - 4
Small Coastal - 9

Construction and Acquisition Program

Source of Funding for new Ships and, Replacements, 1970 - present

NSF 4
Navy 2
State/Private 4

Construction of new or Replacement Ships Planned, 1979 - 1984

NSF

- Large Coastal, 125-140'
- Small Coastal, 85-95'
- Ice strengthened intermediate, ca. 180' - 1

Navy - None

State/Private - none

Senator JAVITS. Mr. Chairman, my staff suggests that we raise the question of multiyear authorizations, which he tells me has not come up.

I don't know if we can do anything about it, but with such a fine galaxy of witnesses, it may be that an opinion on that would be useful.

Senator KENNEDY. Very good.

Dr. SANDERSON. Mr. Chairman, Senator Javits, we have discussed the possibility of multiyear authorizations for several years, informally, as you are aware.

The Foundation feels that there would be considerable benefit to be gained from the continuity of multiyear authorization funds. Science is a long-term activity, and the ability to plan further ahead would be beneficial.

There are a couple of areas of concern which we do have; one is that science is also a very dynamic area, as has been noted several times during the hearings this morning. One would worry that the authorization not have too long a period, otherwise one might begin to be restricted by them.

The other is, frankly, the Science Foundation, we believe, benefits from the exposure to the Congress and the opportunity to explore ideas and to benefit from the suggestions that come up.

If multiyear authorizations are to be found, I think it would be very beneficial to find some alternate means to replace this exchange of ideas.

Senator JAVITS. Well, my own opinion would be that multiyear authorizations are desirable in the interest of science and the interest of the Foundation. We can certainly find the means for giving you exposure to the legislative oversight; there's no problem about that.

So I think what I would like to hear is your best judgment of the idea, divorced from the public relations aspects, and it would have to be so materially superior to the annual authorization as to give us, should we vote for it, a very strong case.

Dr. SANDERSON. I think a case can be made in the area of the continuity, particularly for our basic research programs where there is an advantage to be able to plan several years ahead.

What I would like to do is to provide you with more materials for the record, if I might.

[The materials referred to follows:]

TWO-YEAR AUTHORIZATION FOR THE NATIONAL SCIENCE FOUNDATION

Some advantages of two-year authorizations are as follows:

- o Greater stability in providing Foundation support for critical research/educational projects and programs which require long-term funding commitments and management would be possible.

- o Foundation staff time released as a result of two-year authorizations could be more beneficially used to assess the effectiveness of current programs and research strategies as well as the adequacy of the Foundation's response to the needs of the Nation's scientific and engineering constituencies. Concurrently, the Congress would have increased time for oversight of the Foundation's programs and funding levels.

- o The Foundation's staff would be provided with greater opportunities to expand long-range planning activities and to prepare decision-making position papers for the Congress and its staff on major issues regarding the Nation's short-range, medium-range, and long range outlooks for science and engineering.

- o Additional lead time would be available for the Foundation's staff to consult with local and state Government officials across the country on their specific scientific and technological needs.

Concern over multiple-year authorizations usually centers on the problem of NSF-Congressional interaction. Some feel that, under multiple-year authorizations, Congressional leaders might not have the opportunity to interact adequately with the Foundation staff. This concern, however, could be met by special hearings on matters of interest to the Congress on issues and program concerns.

Adequate flexibility for program adjustments can be provided in a multi-year authorization by inclusion in the authorization Act of specific reprogramming authority and of authority for NSF to seek special authorization for urgent high priority requirements that could not be foreseen when the original authorization request was submitted and which cannot await approval in the next regular authorization cycle.

The Foundation is on record as supporting the concept of a multiple-year authorization. (May 17, 1976, letter from Dr. H. Guyford Stever to Senator Jacob Javits. Copy attached.)

On March 18, 1977 the National Science Board adopted the following resolution:

Resolved that:

> The National Science Board encourages the Foundation to seek a two-year authorization with adequate provision for program flexibility and special hearings on issues of interest to the Congress.

17 MAY 1976

Honorable Jacob K. Javits
United States Senate
Washington, D.C. 20510

Dear Senator Javits:

Thank you for your letter of March 18, 1976 in which you expressed support for increased funding of basic science; the proposed Antarctic Program budget; and concern about the decrease in NSF funds for science education. You also requested my views on the education trend and on the suggestion that two-year authorization of the Foundation's programs replace the present annual reauthorization.

The decrease in funding of direct science education programs, both in dollars and as a percent of the total Foundation budget, reflects three judgments: (1) that many of the objectives of the original programs have been met; (2) that some programs were large, but not clearly effective; and (3) that an effective way to carry out science education is through participation in research programs.

The first judgment derives from data showing that we now have and will have an excess supply of scientists through 1985. Consequently, the need for large-scale Fellowship and Traineeship programs cannot be demonstrated, although some Fellowship programs have been maintained by the Foundation to maintain the quality of the scientific manpower pool. Fellowships in 1968 were $46.1 million and are $15.1 million in our FY 1977 request.

The second judgment applies primarily to retraining elementary and secondary school science teachers. While the retraining programs--the teacher institutes--were demonstrably popular with teachers, there was very little evidence that they had an incremental impact on student performance. Some experiments and demonstrations to establish student effects may be warranted, but it is difficult to demonstrate that the 1968 level for institutes--$34 million--could or should be spent every year. We will be conducting a needs assessment on alternative ways of improving pre-college science instruction, including teacher institutes.

The reductions in Fellowships and teacher institutes more than account for the apparent dollar decrease in science education. But the dollar figures do not give an entirely accurate picture, since we should apply our third judgment to the increases requested for basic research. The increases in basic research requested by the Foundation imply an increase in science education activity not captured by our accounting systems. Since our basic research is carried out primarily in universities, and with the involvement of graduate students and assistants, the true proportion of science education activity supported by the Foundation is higher than the 10 percent reflected in the budget.

We do not know what the "optimal" percentage for science education should be. In the face of leveling enrollments, incentives and programs to enhance quality and efficiency in science education may be more important than the absolute dollar amounts.

There have been compelling reasons for increases in NSF support of basic research. Not the least of these is the shared reluctance of the executive and legislative branches of the government to support research by mission agencies which is not clearly and directly related to the agency's mission. Despite my efforts and those of the National Science Board, there has been a trend away from mission agency support of basic science, a trend that has substantially increased the need for NSF research funds and contributed to the decline in the proportion of NSF funds devoted to science education.

I have considered the question of two-year authorization for NSF before and share your belief that both NSF and science would benefit from the increased stability such authorizations could provide. Although I welcome the opportunity provided by the one-year authorization to discuss annually the programs of NSF with Congress, I believe that the advantages of a two-year authorization are substantial. Now that there are indications that the trend toward detailed earmarking of funds has been reversed, providing NSF with the necessary flexibility to adjust to the changing requirements of science and science education, I would encourage both the Administration and the Congress to support the two-year authorization.

Both as Director of the National Science Foundation and as Science Adviser, I appreciate your continued interest in and support for NSF programs and for the health of U.S. science.

Sincerely yours,

/s/ H. Guyford Stever

H. Guyford Stever
Director

Dr. HACKERMAN. Senator Javits, I would like also to interject here that the National Science Board has not discussed this matter in a formal way; and, therefore, I cannot report on it today.

But I would be very surprised if they would not be interested in multiyear authorization. We will take up this subject at our meeting on March 17–18.

Senator JAVITS. We could conceivably deal with a multiyear authorization and an annual appropriation, or it may be possible to seek to do better on given functions; for example, in the education field, we appropriate enough money in a given year so that if there is a "drag" at the end—Congress is late, or something, preplanning can take place by the educational agencies, and they have the resources with which to meet other requirements of preplanning.

And for practical purposes, we appropriate a year in advance of expenditure; that's really what it comes down to.

There are techniques which can be used, if there is a case. But I must, in all fairness to you, say in advance, there would have to be a strong case, or my colleagues are not going to be persuaded otherwise.

But I do say this: science is a field in which if there were a request for multiyear authorization, so that there could be a planned program for more than 1 year, it seems to me that members would look at that, with the previous position, to say: well, it is science, and it is long-term science, and in this case we have to look at it with an open mind because it may be justified.

Dr. SANDERSON. Senator Javits, we appreciate your remarks, and we would like to work with you and your staff on this matter. We will be taking it up in the next couple of weeks.

Senator JAVITS. Thank you Mr. Chairman.

Senator KENNEDY. Thank you, very much.

Senator Chafee?

Senator CHAFEE. I wanted to ask a quick question.

Are you able to keep your top people? Or did that pay raise come at a satisfactory time, in a satisfactory amount?

Dr. ATKINSON. Senator, we are in a complicated stage in the history of the Foundation. Many of the senior positions are either vacant or filled by "acting" appointments. We hope to get some closure on these matters in the next month. The pay raise is going to make quite a difference in our ability to recruit talent to the Foundation.

But there is a very unique aspect of the Foundation that cannot be underestimated, and that is the fact that we depend very heavily on what we call rotators. These are scientists who leave their university or their laboratory to serve as program officers at the Foundation for 1 or 2 years. These people come with the clear view of returning to their university or laboratory, and are not driven primarily by monetary considerations, but more by a service to their science.

So yes, the pay raise is going to be very helpful at the upper levels, but I do want to emphasize the notion of rotators.

Dr. SANDERSON. Senator Chafee, in further response to that question, I think this committee has been aware over the past several months or year, that we have had some difficulties in our relations with the Civil Service Commission, which we are working with our congressional committees and with the Commission to resolve.

That might have a potential for some fairly serious impacts on our recruiting, to keep some of our top management people, but we are working, trying to keep the Senate committee and the other committees informed on this activity.

Senator CHAFEE. I don't want to get into too much detail, but—the Civil Service Commission, what kind of a problem are you talking about?

Dr. SANDERSON. At the time the National Science Foundation was established, in 1950, it was given broad authority in its act to recruit technical and professional personnel—based on the Director's determination of need within policies established by the Board, outside of the normal civil service competitive system. This enabled NSF to seek the best talent anywhere in the country and bring it in to the Foundation, rather than using the formal civil service process and the grade classifications established by the Commission.

We have used that excepted authority for about 25 years, now, in a fairly consistent manner. In the last approximately 3 or 4 years, the Civil Service Commission has begun to challenge our authority for its use in certain positions within the Foundation.

We are currently trying to resolve this difficulty. Particularly in reviewing certain professional positions at NSF—in defining the use of the words "technical" and "professional,"—it is the determination by the Board that that has to include some of the top managers in the Foundation, as well as the scientists who are actually hands-on program officers.

A scientific and a professional management capability is required to run a science organization that is somewhat unique.

I will be pleased to provide for the record a copy of the most recent correspondance which summarizes the issues in dispute.

[The material referred to follows:]

UNITED STATES CIVIL SERVICE COMMISSION

WASHINGTON, D.C. 20415

30 DEC 1976

Honorable Richard C. Atkinson
Acting Director
National Science Foundation
Washington, D. C. 20550

Dear Dr. Atkinson:

For some time now, the Civil Service Commission (CSC) and the National Science Foundation (NSF) have been attempting to resolve certain questions concerning the use by NSF of its excepted appointing authority included in Section 14(a) of the National Science Foundation Act of 1950, as amended. The issues were raised in our evaluation of personnel management in NSF in 1972, and the basic problems we found were set forth in our report dated March 1973. In the more than three years that have elapsed since we issued that report, our respective staffs have been working to resolve the issues between us in a proper manner, fully consistent with the intent of applicable law. To date we have not been successful, and that is why you and I met on October 12, 1976. We agreed to accelerate our efforts so that, if possible, the matter could be settled within 30 days. Although we did not quite meet that somewhat ambitious target date, I believe that we are now at the point where final actions can be taken to bring this entire matter to a close. This letter outlines both the basis for that conclusion and the actions we deem necessary.

As you know, the principal personnel authority provided to NSF is title 5 of the U. S. Code -- the basic competitive civil service authority provided for most government organizations. In addition, however, NSF was given a special excepted personnel authority, ". . . . to employ and fix compensation, without regard to title 5 of the U. S. Code, for such technical and professional personnel as the Director of NSF deems necessary to accomplish the mission of the Foundation." The National Science Board is responsible for establishing policy guidance for the use of this excepted appointing authority. Our longstanding controversy revolves around whether the Foundation's use of its excepted authority is consistent with the intent of applicable law. The two key issues that have evolved are these:

- What was meant by "technical and professional" within the context of the National Science Foundation Act of 1950, as amended, and

- Within the parameters of what was meant by these terms, has NSF established and graded excepted positions in a manner consistent with the intent of the law?

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The basic concern we addressed in our 1973 report was that NSF was using its excepted authority in a way that was not intended by the NSF Act and, further, that such use violated applicable provisions of title 5 personnel laws. Specifically, NSF was found to be using its excepted authority to establish administrative and support type positions not contemplated by the terms "technical and professional" as used in the NSF Act. In addition, NSF was found to have graded many such positions significantly above the grade levels that would be assigned if these positions were properly evaluate in accordance with CSC standards issued pursuant to the classification provisions of title 5. In other words, NSF was found to be using its excepted authority in a manner that had the effect of violating the intent of its own organic statute as well as certain provisions of title 5, U. S. Code. Clearly, the Commisson could not countenance or condone such action; and our efforts since we issued our report in 1973 have been devoted to bringing about proper corrective action. It does not overstate the case to say that NSF has largely resisted these efforts, and therein lies the basis for the as yet unresolved controversy.

You wrote to me on October 15, 1976, following up on our October 12 meeting. The main point of your letter was to assert once again that NSF's historical use of its excepted authority for the positions currently at issue between us is not only proper and fully consistent with legal intent, but also reflects no basic change in NSF's use of its excepted authority to which CSC has never before objected. Specifically, you indicated that (1) the words "technical and professional" have an ordinary meaning in the language that takes in "legal and managerial" professionals, (2) the legislative history provides guidance that the terms "technical and professional" are intended to be broader than "scientific and engineering", and (3) there is a 25 year operating history which supports the use of the NSF excepted appointing authority for the employment of professional staff other than scientists and engineers.

As you know, our careful study of this matter has brought us to a position that differs with the view expressed above. You agreed to furnish additional documentation to support your position, as a result of our meeting on October 12. With the cooperation of your staff, we have reviewed those documents and all others we have been able to obtain which shed light on both the legislative intent and the way NSF has used its excepted authority throughout its operating history. Here is what we found:

1. The National Science Board first prescribed policy for use of the excepted appointing authority by the Director at its fifth meeting on April 5, 1951. The policy provided for six full-time regular positions--namely, the Deputy Director, the General Counsel and the heads of the four divisions set forth in the Act. At subsequent meetings

the Board, from time to time, has modified and expanded this initial narrow construction of its excepted appointing authority. These modifications have resulted in a gradual increase in the number of excepted positions and appointments, a gradual deepening of the organizational levels at which the authority is used, and a gradual expansion of the grade range covered by NSF excepted positions.

2. The Board's 1962 modification was quite significant; it superseded all previous prescribed policy guidance and, for the first time, focused on compensation for excepted positions. The new policy adopted by the Board at that time provided that pay for excepted employees, "should be set at salaries comparable with those the incumbents could expect to receive from progressive public and private employers." In this action the Board decided to use its excepted authority for a purpose not intended by the NSF Act: to significantly broaden the classes for which the Foundation's excepted authority could be used and thereby to attempt to maintain salary comparability with the private sector. This modification served to open the door for substantially increased use of the authority for administrative and support type positions. For the first time, use of the excepted authority for positions equivalent to GS-15 and below was authorized. Previously the excepted authority had been used only for full time regular positions at grade levels equivalent to supergrades (grades GS-16 to 18).

3. What the Commission found in 1972 was that, although the excepted authority apparently had been used appropriately for employing highly qualified scientists and engineers, it had also been used improperly with respect to administrative and support positions and employees, to accomplish three kinds of purposes clearly not intended by the NSF Act, as amended: (a) to provide salary increases equivalent to supergrade levels to personnel who were already employed by the NSF, by "promoting" them from competitive civil service to higher grade NSF excepted positions; (b) to appoint to NSF excepted positions individuals who had been rated ineligible by the CSC because they were not qualified for appointment to comparable competitive civil service positions; and (c) to appoint to NSF excepted positions individuals who were not within reach and therefore not eligible for appointment to comparable competitive civil service positions.

We concluded that such actions constituted misuse of NSF's excepted authority. In the circumstances, the Commission had no alternative but to address this matter in the strongest possible terms. What was essentially at stake was violation by NSF of the government's personnel laws set forth in title 5, U. S. Code. Accordingly, our March 1973 report required NSF to review all excepted positions within 60 days, convert to the competitive service all but those that are technical and professional--mission program oriented, and terminate the appointments of the incumbents of such positions unless they were eligible for reinstatement or could be reached on an appropriate Commission register.

Following delivery of the Commission's report to your predecessor, Dr. Stever, this matter was the subject of a number of staff-level discussions, and several letters were exchanged. Basically, NSF took issue both with the substance of CSC's concerns and with our authority to raise the issue and require corrective action. When efforts to achieve the corrective actions required in our report failed, the Commission was obliged to take formal action. On May 8, 1974 the Commissioners decided, on the basis of a full review and analysis of the substantive and legal issues involved, that 34 NSF excepted positions must be brought into the competitive service. Accordingly, in accordance with responsibilities delegated by the President, and under the statutory provisions of the Civil Service Act now codified into title 5, U. S. Code, the Commission directed that such action be taken. We so informed your predecessor, Dr. Stever, by letter dated May 9, 1974, and we offered the assistance of our staff to help work out the details and overcome whatever difficulties might be encountered.

Subsequent to this action by the Commission, Dr. Stever and I met and agreed that our staffs would cooperate in drafting a new policy statement relative to the use of NSF's excepted appointing authority, to replace the guidance issued by the Board in 1962. This was done, with much earnest work by both sides, and the resultant policy statement was approved by the National Science Board on October 18, 1974. That document represent what the Director of NSF, the National Science Board and the Civil Service Commission agreed was a responsible, proper, and legal interpretation both of section 14(a) of the NSF Act and of the intent of title 5 in its relatic ship thereto. We know of nothing that has occurred since that time to warrant a change either in our then-agreed-upon interpretation of law or in NSF's policy in this matter.

As a consequence of the revised policy, NSF soon thereafter took action to convert to the competitive service the incumbents of several of the 34 positions in question. Later, on February 28, 1975 the Foundation transmitted to the CSC material relating to 18 positions NSF proposed for supergrades. This letter also identified four positions NSF desired to retain in the excepted service. In addition, the letter expressed the

Foundation's wish to retain its attorneys under its excepted authority. In response, we advised NSF of (1) our tentative classification decisions on the positions proposed for supergrade, (2) our view that the four positions proposed for retention in the excepted service did not meet the agreed-upon criteria in NSF's revised policy, and (3) our view that attorneys should be appointed under the regular Schedule A appointing authority provided by CSC for government-wide use.

Understandably, NSF staff expressed both concern and disagreement with certain aspects of CSC's response. Our staff expressed to yours our willingness to receive further clarifying information on any points of disagreement, and to work cooperatively to resolve any issues. There was no response. Meanwhile, NSF reorganized the Office of the Assistant Director for Administration, where a number of the excepted positions we questioned existed. Efforts were made to strengthen certain of these positions, while others were eliminated. Learning of this effort, our staff took the initiative once again to work with yours in a further attempt to resolve this longstanding issue. As a result, on March 24, 1976 your staff forwarded for CSC review and advice official descriptions of eight key positions proposed for classification in supergrade (GS-16 through GS-18) levels. Our staff reviewed these documents carefully, desk audited them by interviewing the incumbents and supervisors of these positions, and thoroughly studied all relevant supporting information made available by your staff. From this careful classification analysis and upon staff review, it was tentatively concluded that only one of the eight positions in question warranted a supergrade; the remainder ranged from GS-13 to GS-15, based on our evaluation using government-wide classification standards issued pursuant to title 5, U. S. Code.

CSC staff formally conveyed the results of this classification review to your staff on August 13, 1976. That transmittal both invited official response and offered the cooperation of CSC staff in further efforts to bring this matter to a proper conclusion in the best interests of all concerned. Until your call and our meeting of October 12, however, there was no response.

If I have belabored the foregoing review of our respective agencies' interactions on this matter, forgive me. I felt it was necessary, however, to put this entire issue in a proper perspective showing the long and earnest efforts that have been made to work our way through a difficult and complex matter. That brings us to the present time, what the Commission has done as a result of our meeting on October 12, and what the Commissioners have finally decided in this matter.

<u>First</u>, this is what we have done since October 12:

1. We have reviewed carefully the information and the documents that were submitted in connection with our October 12 meeting, including the so-called "Mitchell Report" you provided and your letter of October 15 setting forth the facts that NSF believes demonstrates a consistent use of its excepted authority throughout its history.

2. We have reviewed our March 1973 evaluation report, staff papers, memoranda of law from our General Counsel, and the correspondence and exchanges of information that have taken place between our two agencies over the past 3 years.

3. We have obtained and analyzed additional information requested from and provided by your staff: (a) excerpts from the minutes of NSF Board meetings relating to the policies that have been adopted regarding the Director's use of his authority; (b) records of all personnel appointment actions taken under this authority from 1960 to 1974 to determine when, where, and how the authority has been used; and (c) pertinent excerpts from several House Appropriation Subcommittee hearings--those cited in your October 15 letter and all others since 1952.

4. We have contacted appropriate oversight committee staffs on the Hill for information and clarification of issues relating to the matter at hand.

While this effort has required a great deal of time and expense on the part of the staffs of both of our agencies, and is the principal reason for our being unable to meet the 30 day target we were aiming at for final resolution of this matter, we felt it was necessary to have the relevent facts and legal issues fully and completely presented to the Commission before we reviewed the May 8, 1974 decisions we made in this matter.

Second, here is what we have concluded as to the matters at issue, and why:

1. NSF's basic personnel authorities are in title 5 — the basic competitive civil service authority for most agencies. The special excepted authority given to NSF by the NSF Act of 1950, as amended, to appoint "technical and professional" personnel was intended to be used as an exception, when the normal title 5 personnel authorities are not appropriate or sufficient.

2. The law did not intend that NSF should use its excepted authority for administrative and support positions. Although the legislative history of the NSF Act itself is silent on this subject, it has been referred to in appropriation hearings. In the 1952 House Appropriation Subcommittee hearings when the Subcommittee Chairman, Mr. Albert Thomas,

questioned the propriety of using the authority for the General Counsel position he said: "The intention of the law was for scientists." Again, during hearings in 1961, Mr. Thomas expressed his concern on this matter, and warned: ". . . . use your authority wisely, and do not bring the roof down on your heads." The terms "technical and professional" in section 14(a) of the Act referred primarily to technical and professional positions in engineering and recognized sciences that are a part of the direct line programs of the Foundation, as established by the original Act and subsequent amendments, and do not include the types of administrative and support positions for which the authority has been used in more recent years.

3. NSF has also used its statutory excepted appointing authority to violate title 5, U.S. Code and to subvert merit principles by: (a) appointing individuals who were not qualified or eligible for proper appointment to comparable competitive civil service positions, and (b) providing salary increases to current NSF personnel by "promoting" them from competitive civil service positions to excepted positions.

4. The policy that was developed by NSF and CSC staff, approved by the National Science Board at its 167th meeting on October 17-18, 1974, and publicized in NSF Staff Memorandum O/D 74-49, dated October 22, 1974, is a proper and legal interpretation of Section 14(a) of the NSF Act of 1950, as amended. That policy set forth criteria for the use of NSF's excepted authority that assure compliance both with the NSF Act and with title 5 personnel requirements and, at the same time, enable the Director of NSF to obtain the technical and professional personnel necessary to carry out the responsibilities of the Foundation. As approved by the Board in October 1974, the policy and criteria were as follows:

"1. Appointments to positions in the NSF will normally be made in accordance with the provisions of title 5, U.S. Code, and applicable CSC laws and regulations except as provided in (2) below.

2. The excepted Authority to appoint technical and professional personnel necessary for the discharge of the Foundation's responsibilities will be used only in the following circumstances.

   (a) Appointments of personnel to top management positions. These positions include Assistant Directors, Deputy Assistant Directors, and persons holding equivalent positions. All such appointments shall be subject to the approval of the Director.

(b) Appointments to positions which clearly require specialized abilities based on scientific or engineering training and/or experience. All such appointments must be approved by the Director or the Deputy Director.

(c) Appointments of professional staff to the National Science Board (limited by law to a total of five).

(d) Appointments in special circumstances with concurrence of the CSC.

The policy provides for using the excepted authority for filling positions which clearly require specialized scientific or engineering training and/or experience and in filling certain top level executive positions. This was done to assure stability and consistency in the terms and conditions of employment among the very top levels of management in the Foundation. The policy also recognizes what the Commission has contended all along: that administrative and support positions below these levels and Attorney positions are appropriately filled and compensated through the Foundation's basic appointing authority found in title 5, U.S. Code.

Accordingly, the Commissioners and I have decided, on the basis of a full review and analysis of the issues involved, that the following actions must be taken forthwith by NSF to bring this entire matter to a proper and legal conclusion:

1. If NSF desires to submit any further clarifying information on the 8 key positions in response to our classification advisories dated August 13, 1976 (the 8 positions are listed in Attachment 1), such information must be submitted no later than 15 days from your receipt of this letter. We shall take any information submitted into account and issue certificates for those positions at GS-15 and below and recommend to the Commission that formal classification action be taken on the positions that are determined upon staff review to warrant supergrades.

2. Current and properly certified position descriptions and classification evaluation statements must be submitted within 15 days for the 11 positions listed in Attachment 2. The Commission will issue certificates for the proper classification of these positions as soon as possible thereafter. If NSF wishes to submit any comments on these positions, in response to the classification advisories we furnished to you on August 20, 1975, we will consider them fully.

3. Current and properly classified position descriptions and classification evaluation statements must be submitted within 15 days from your receipt of this letter for the 4 positions listed in Attachment 3. These four positions were among the 34 positions brought into the competitive service by formal Commission action on May 8, 1974, but NSF has not yet submitted the information required for a proper CSC review of these positions. The Commission staff will audit the positions, as necessary, and will advise NSF as to their proper classification. If necessary, the Commission will also issue certificates for the proper classification of these positions, in due course.

4. The 5 Attorney positions listed in Attachment 4 must be converted from the NSF excepted authority to Schedule A, the excepted authority used for appointing individuals to attorney positions throughout the executive branch of government. Before such conversion takes place however, proper classification of these positions must be verified. Accordingly, current and properly certified position descriptions and classification evaluation statements must be submitted within 15 days from your receipt of this letter. The Commission will audit, as necessary, and will advise NSF as to the proper classification of these positions. Thereafter, as necessary, will issue certificates for the proper classification of these positions.

For the record, it should be noted that, although the fifteen day time periods allowed for carrying out the foregoing action may seem unreasonable, from the information available to our staff this appears not to be the case. We understand that most of the staff work required for completion of the above actions has already been completed or is quite advanced. Therefore, meeting these deadlines should not put an unreasonable burden on your agency. If such is not the case, however, with any particular action called for above, the Commission will grant a reasonable extension upon a timely showing by NSF that circumstances warrant it.

Since the first time this issue was taken up by the Commission we have been concerned about the possible adverse impact on individuals of the corrective action that would be required, as well as about the impact on NSF as a whole. The fact that NSF has improperly used its excepted authority and that positive action must be taken to bring the agency back into legal compliance is, of course, a paramount consideration. From the outset, however, we have been mindful of the need to do everything reasonably possible to prevent adverse impact. It was for this reason the Commissioners and I acted as we did, on May 8, 1974, to bring the 34 improperly excepted positions into the competitive service in such a way that any affected employees would be entitled to salary retention indefinitely. The same provision has now been made for any other individual whose positions are to be downgraded and brought into the competitive service as a result of the further corrective actions required by this letter. Eligible employees may be recommended for conversion to career or career-conditional employment under section 315.701 of our regulations. Any recommendation for conversion must be submitted to the Commission no later than 90 days from the date of this letter, however, for such benefit: to obtain. We recognize the "psychological" impact that these downgradin: actions may have on affected individuals, but there is little we or you can do to enhance people's feelings about having their positions properly classified at a lower grade. Nonetheless, it should be recognized that we have dealt as effectively as the law allows with the economic issue of saved pay; no one affected by these corrective actions will lose even one dollar of current salary.

This Commission shares fully the concern of NSF management that the Foundation continue effectively, and that correcting improper personnel practices be done in a way that permits the organization to function as well as possible in carrying out its mandated programs. We have held that concern in view from the outset and in all of our efforts to date; and we will continue to work with your staff toward that end as we bring this matter to its proper conclusion.

I have provided a copy of this letter to Senator Kennedy and Representativ Teague, in view of their expressed interest in these matters.

By Direction of the Commission.

Sincerely yours,

Robert Hampton

Robert E. Hampton
Chairman

Attachment 1

1. Director, Division of Grants and Contracts
2. Deputy Director, Division of Grants and Contracts
3. Plans and Policy Officer, Division of Grants and Contracts
4. Director, Division of Personnel and Management
5. Deputy Director, Division of Personnel and Management
6. Special Assistant
7. Director, Division of Information Systems
8. Director, Division of Financial and Administrative Management

NOTE: Name deleted in accordance with the Privacy Act of 1974.

Attachment 2

1. Special Assistant
2. Special Assistant
3. Assistant General Counsel
4. Budget Officer
5. Program Officer
6. Audit Officer
7. Director, Programming Office
8. Head, Planning and Policy Office
9. Congressional Liaison Office
10. Associate Director for Public Programs
11. Community Affairs Branch Chief

NOTE: Name deleted in accordance with the Privacy Act of 1974.

Attachment 3

1. Program Analyst
2. Special Assistant
3. Director, Health Services
4. Head, Evaluation Staff

NOTE: Name deleted in accordance with the Privacy Act of 1974.

Attachment 4

1. Attorney
2. Attorney
3. Attorney
4. Attorney
5. Attorney

NOTE: Name deleted in accordance with the Privacy Act of 1974.

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE DIRECTOR

JAN 14 1977

Honorable Robert E. Hampton
Chairman
U.S. Civil Service Commission
Washington, D.C. 20415

Dear Mr. Hampton:

Your letter of December 30 came as a great disappointment. I had come away from our personal conversation in October convinced that a basis had at long last been established for reasonable dialogue and accommodation. Instead, I fear we are on the brink of an unfortunate confrontation, one we have long and diligently striven to avoid. This dispute has had a destructive impact on NSF staff morale, and has impeded the introduction of important NSF management changes, which are needed for the effective operation of the Agency. We can, of course, still draw back from this brink. With that in mind, I should like to respond to your letter as carefully and thoroughly as I can.

The Commission's March 1973 personnel management evaluation report that first raised the basic issue also identified, as I assume such reports generally do, certain faults in our Agency's personnel administration practices. All of these, including a few referred to in your letter, have long since been corrected in the ordinary course. My understanding had been that even where disagreements initially appeared, the Commission and the Foundation have reached closure on every point but the one now in issue--the meaning of NSF's statute on the extent of the NSF Director's excepted appointment authority.

I hope that we can be clear on the issue that remains to be resolved. In particular, your letter asserts that NSF "violated" Title 5 personnel laws, that NSF's excepted authority had been "used improperly" with respect to administrative support positions and employees, that NSF's actions constituted "misuse" of NSF's excepted authority, and so on. Assuming the interpretation of the NSF Act that your letter espouses, these assertions are understandable. However, they are conclusions that follow from your interpretation of the Act, with which the Foundation does not concur.

I trust you will advise me immediately if my understanding is incorrect. Otherwise, I believe we can agree that whether the Foundation's use of its excepted authority has been proper and legal depends on whether the Foundation is correct in the interpretation of the NSF Act it has been following and acting upon in good faith for over twenty-five years. My concern, in short, is that both agencies agree and understand that the issue now between us is one of legal interpretation on which decent men can disagree, if not with equal cogency, nonetheless with equally honest intention to obey and uphold the law.

Your letter contains some assertions concerning what was "clearly intended" by the crucial language in our Act that authorizes the Director to employ such "technical and professional personnel" as he deems necessary for the discharge of the responsibilities of the Foundation "without regard to" the personnel laws and classification laws. Your letter concedes, however, that no support for those assertions of intent can be found in the "silent" legislative history. It derives such little support as is offered for these assertions from an isolated comment by Representative Albert Thomas that is taken quite out of context. Though not involved in the formulation of the NSF Act other than as a member of the full House, Mr. Thomas was for many years Chairman of our appropriations subcommittee. He was kept continually abreast of the Foundation's use of the authority because of his concern to keep it and NSF's staff budget within proper bounds, and he addressed himself to it in hearings on several occasions. He always concluded that the use of the authority was within proper bounds. On the very occasion in question when he checked the propriety of the General Counsel's appointment under its excepted authority, obviously to his satisfaction,* he specifically endorsed NSF's use of the authority, saying: "We are not falling out with you on anything you have done in that regard. You have good men, and you are going to have to pay them to hold them."

Subsequently, in our 1975 authorization hearing, subcommittee Chairman John Davis elaborated:

> "To carry out its mission, the Foundation needs not only topflight scientists and educators but effective managers and other administrative professionals who can initiate its unique programs, manage them, and keep them responsive to our changing national requirements. The Congress recognized this need by including broad excepted authority for the employment of such individuals in the enabling legislation."

Nowhere in the history of our appropriation or authorization hearings is there language to support your interpretation that Section 14(a) of the NSF Act "referred primarily to technical and professional positions in engineering and recognized sciences that are a part of the direct line programs of the Foundation." Moreover, Senator Kennedy and Representative Teague, our current authorization committee Chairmen, expressed to you

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*My understanding is that even now the Commission itself accepts the excepted professional appointment of our General Counsel.

in letters of September 17 and September 20 that your interpretation is erroneous and that the National Science Board's 1976 resolution "appropriately reflects the meaning of the statute and the underlying Congressional intent." This resolution, not mentioned in your letter, is the current policy under which I am operating and allows for excepted appointments to positions requiring "specialized scientific, engineering, legal, or managerial training and/or experience.

In any event, strong legislative history indeed would be required to support a construction of the plain words "technical and professional personnel" so unnatural and as contrary to twenty-plus years of practice as that which your letter espouses. It strains the language past an obvious breaking point, for example, to assert that lawyers are not professionals, or that experts in such complex fields as grant and contract administration or financial management are not professionals.

Moreover, the gossamer distinction proposed to be drawn between "the very top levels of management", conceded by your staff to be professional administrators, and "administrative and support positions" at the next levels, asserted not to be, ignores what it means to be a professional. It is advanced education or training in specialized skills that mark a professional, not organizational level. To be sure, professionals are normally concentrated at higher levels of management. But no principled approach can justify conceding the obvious professional status of NSF's Assistant Director for Administration, an expert in accounting and financial management, while denying the professional status of its Director of Financial and Administrative Management, an expert in precisely the same fields.

NSF's use of its excepted authority to appoint legal and managerial professionals goes back to the earliest days of its existence.

Among the first six excepted appointments under the NSF Act were the Foundation's first lawyer and its first professional administrator. The Civil Service Commission, which had unsuccessfully opposed the excepted appointment authority in Congress, not only acquiesced in NSF's administration of the authority for more than two decades, but actually assisted in the development of the system in the early 1960's. With subsequent growth in NSF's program responsibilities and budget, its staff naturally grew. Excepted appointments of technical and professional staff grew correspondingly. We see nothing unusual in the consequent natural and predictable increase in the absolute numbers of excepted appointments referred to in your letter. Classified appointments grew as well, and the balance between classified-service and excepted appointments has remained roughly constant over the years.

By the same token, as the staff structure of NSF deepened with increasing size, the organizational levels at which technical and professional personnel served and were hired under the excepted authority deepened correspondingly. So did the organizational levels at which nonprofessional classified employees served. Again, that seems predictable and natural. And again, in any event, it seems to us plain that a person's professional standing does not depend on his organizational level. For that matter, the Commission concedes, so far as I am aware, the status as "scientific" professionals of many NSF employees at lower levels than most of those whose status is now at issue.

Further, I would like to comment on our differences over appropriate levels of pay. Our statute specifically and deliberately permits NSF's Director to fix the compensation of technical and professional staff "without regard to" the Classification Act and the General Schedule. NSF, however, continues to recognize and take seriously the Commission's expertise and formal role in classification and setting pay.

We have carefully compared our GS-equivalent grades for critical positions with grades for the most closely analogous positions in agencies and bureaus with roughly similar missions and find them very much in line. The grades the Commission has proposed for the same positions, by contrast, are lower than those in the other agencies in almost every case and would put NSF at a serious competitive disadvantage.

As I promised at our meeting, I was prepared to once again examine all the cases at issue and to take a conservative approach, resolving borderline situations downward in an effort to agree with the recommendations of your staff. Although not required to do so, the Foundation has long made it a practice to use Civil Service Commission classification standards as guidelines for setting the pay levels of its excepted employees. For most positions, this approach yields a satisfactory grade pattern and simplifies administration of the pay system. The Foundation's special authority, however, enables it to take other pertinent factors into account in setting pay, not recognized by CSC standards. For example, in the case of individuals employed by NSF for one or two year appointments while on leave of absence from universities (known as "rotators"), the Foundation adjusts the pay level and pay step to achieve a "no loss-no gain" salary level when compared with the person's salary at the university.

By the same token, in the case of the top management positions of this agency, the Foundation uses the CSC standards as guidelines, but takes into account factors which are unique to science agencies in general and to NSF in particular. The CSC standards generally do not exceed the GS-15 level in their description of classification factors and require considerable judgmental extrapolation, in any case. Too, they are written in broad terms generally based on organizational patterns in large agencies in order to cover as many positions as possible in the Federal service. For this reason, the CSC standards are not as effective as guidelines for the top professional management positions in NSF as other standards may be for their occupational categories. Our excepted authority enables the Foundation to examine the unique factors and give them appropriate weight in the classification process.

By exclusively applying the CSC standards in classifying these positions, the CSC position classifiers have not given the necessary consideration to the scope and significance to the nation's welfare of the National Science Foundation. Its role as an important independent agency is ignored and it is compared to bureaus or other subdivisions of other agencies. Too much stress is laid on the number of employees in the agency. On the one hand, this stress shows a failure to appreciate the fact that the Foundation accomplishes its mission by cooperative arrangements with thousands of academic and other institutions throughout the country and in the international arena. On the other hand, it penalizes us for our stress on economical personnel utilization and our emphasis on increasing staff productivity through the introduction of modern technology into our operations.

I have had my staff carry out a reexamination of the positions under dispute. As evidence of my desire to resolve this issue, I am proposing the following series of actions:

A. First, there are seven positions that I have determined may properly be placed in the grades proposed by your staff. In my view, a number of these positions represent borderline cases where the determination could easily be one grade higher. This is especially true since all of the incumbents are superbly qualified for the grades that NSF has assigned to them, and had they not suffered the misfortune of employment here, would no doubt be at these or higher grades in other science agencies.

	Incumbent	Position	Current NSF Classification	CSC View	NEW NSF Classification
1.		Director, Division of Grants & Contracts	EE-I	EE-I	EE-I
2.		Director, Programming Office	EE-II	EE-I	EE-I
3.		Head, Planning & Policy Office	EE-I	EE-I	EE-I
4.		Assoc. Director for Public Programs	EE-I	EE-I	EE-I
5.		Deputy Director, DGC	EE-I	GS-15	EP/GS-15
6.		Plans & Policy Officer, DGC	EE-I	GS-14	EC-14/ GS-14
7.		Audit Officer	EE-I	GS-15	EP/GS-15

B. Second, there are five positions that I agree may be placed in lower grades, though not so low as proposed by your staff. Our own careful review

NOTE: Name deleted in accordance with the Privacy Act of 1974.

of these positions--in the context of the new alignment of positions which will result from the sequence of actions set in motion here--indicates that these new levels are appropriate.

	Incumbent	Position	Current NSF Classifications	CSC View	New NSF Classification
8.		Special Assistant, DPM	EE-I	GS-13	EC-14/ GS-14
9.		Deputy Div. Director, DPM	EE-I	GS-14	EP/GS-15
10.		Special Assistant, O/D	EE-II	GS-13	EP/GS-15
11.		Chief, Congressional Liaison Office	EE-I	GS-14	EP/GS-15
12.		Program Review Officer	EE-I	GS-13	EP/GS-15

C. There is one position that CSC has said should be an EE-I, but which NSF recently reclassified to EE-II. The incumbent is currently on detail to the Office of Science and Technology Policy to assist in establishing it and is being considered for a permanent assignment there.

	Incumbent	Position	Original NSF Classification	CSC View	Current N Classification
13.		Special Asst. to the Director	EE-I	EE-I	EE-II

D. Next are positions which have not previously been discussed. The incumbents of asterisked positions currently hold grades which are one grade higher than those which are shown. The downgrading of these asterisked positions will be in consonance with the new grade patterns within the Office of Government and Public Programs and the Office of Planning and Resources Management, which will emerge when the actions outlined here are taken.

	Incumbent	Position	NSF Classification
*14.		Community Affairs Branch Chief	EP/GS-15
15.		Program Analyst	EP
16.		Special Assistant	EC-14
*17.		Head, Evaluation Staff	EE-I

E. NSF strongly disagrees with the CSC view on five key managerial positions above GS-15. These five positions play a primary role in the NSF top management structure, and the grades proposed by CSC do not adequately reflect their responsibilities and importance to the agency. The proposed

NOTE: Name deleted in accordance with the Privacy Act of 1974.

grades are unreasonable in comparison with similar positions in other science agencies. As pointed out on pages 4 and 5, CSC standards do not provide adequate guidelines for these positions, and I have used NSF excepted authority to accommodate unique job factors and cross-agency comparability. Implementation of the recommended downgradings of the small cadre of top management in my staff offices and the Administration Directorate is simply unreasonable, and would seriously impair my ability to carry out our mission effectively.

	Incumbent	Position	NSF Classification	CSC View
18.		Director, Div. of Personnel & Management	EE-I	GS-15
*19.		Director, Div. of Inmation Systems	EE-I	GS-15
20.		Director, Div. of Financial & Administrative Management	EE-I	GS-15
21.		Assistant General Counsel	EE-I	GS-15
*22.		Budget Officer	EE-I	GS-13

The two askerisked vacancies are being filled in an "Acting" capacity by

F. Last are six professional positions below the supergrade level which NSF proposes to retain under current appointments.

	Position	NSF Classification
23.	Director, Health Services	EP
24.	Attorney	EP
25.	Attorney	EP
26.	Attorney	EP
27.	Attorney	EP
28.	Attorney	EP

I particularly regret that we have been unable before this point to enter into serious two-sided negotiations looking toward real accommodations of our differences. NSF neither arrogates to itself nor concedes to the Commission any right to make unilateral determinations on proper interpretation of the law. Such authority as the Commission has to define its own jurisdiction--the scope of the competitive service and the coverage of the classification laws--derives from precisely those provisions of Title 5 that the NSF Director is authorized to disregard in employing technical and professional personnel he deems necessary for the discharge of the responsibilities of the Foundation.

Surely the scope of the problem is now so narrowed that a final joint review by our classification staffs should be able to achieve agreement

NOTE: Name deleted in accordance with the Privacy Act of 1974.

on the few remaining cases. Had we done this earlier, I believe that the scope of the misunderstanding might have been sharply reduced and that the situation might not have deteriorated to the point it has. Our NSF Congressional oversight committees have directed us to make every effort to seek a reasonable solution. For our part, we are eager to go that extra mile to settle the remaining classification questions.

In any case, to avoid delaying any longer the reclassification actions with which we agree, I have directed my staff to begin implementation immediately. We will also move ahead with those cases which we propose to downgrade less than the Commission has tentatively concluded. Because your letter arrived at the onset of a holiday weekend, we have had less time than we would like to complete the work. Nevertheless, we enclose the material you requested on all positions except 2, 7 and 23 through 28 above. The remaining material will be submitted shortly.

I deeply regret the inability of our two agencies to being this matter to a reasonable conclusion. While the statutory authority interpretation seems irreconcilable, I hope the Commission will work with us to seek a constructive resolution of the other questions which remain. I should like to thank you again for your personal cordiality and, in light of your impending departure, to wish you all the best for the future.

Sincerely,

Richard Atkinson

Richard C. Atkinson
Acting Director

Enclosure

Senator CHAFEE. Thank you. And thank you, Mr. Chairman.

Senator KENNEDY. The subcommittee will stand in recess until 9:30 on Thursday morning.

[Whereupon, at 12:20 p.m., the subcommittee was recessed to 9:30 a.m. on Thursday, March 3, 1977.]

NATIONAL SCIENCE FOUNDATION AUTHORIZATION LEGISLATION, 1977

THURSDAY, MARCH 3, 1977

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

The subcommittee met, pursuant to notice, at 9:43 a.m., in room 4232, Dirksen Senate Office Building, Senator Edward M. Kennedy (chairman of the subcommittee) presiding.

Present: Senators Kennedy and Schweiker.

Senator KENNEDY. We will come to order.

Today we are holding our second day of hearings on the National Science Foundation budget request for fiscal year 1978.

On Tuesday, we heard from officials of the NSF. Today we will hear from witnesses from the academic, industrial and public sectors on their recommendations with regard to the pending budget.

Also with us later this morning will be Dr. Alexander Rich of MIT, who is a member of the National Science Board and who will convey to the Board the comments of the witnesses this morning.

On Tuesday a number of issues of particular concern arose which we would like to discuss today with our outside witnesses. They include:

The importance of increased funding for basic research and for the purchase of scientific instrumentation and equipment.

The need for more opportunities for young researchers to obtain research grants and fellowships.

The need to provide opportunities for minorities, women and the handicapped in science.

The need for innovative science education programs to improve the quality of precollege science education.

The need to increase the participation of 2- and 4-year colleges in NSF programs.

Opportunities which may exist to increase the participation of industry in NSF-funded basic research programs and the costs and benefits of industrial involvement in federally funded basic research.

The need to provide citizen groups with direct funding so they can prepare high quality scientific and technical studies—studies which can meet stringent tests of scientific objectivity and merit and which are presented in a format readily understandable by the general public.

I expect that our witnesses today will be able to give us some good suggestions on how we can address these problems. We will welcome their recommendations on how our subcommittee can help the NSF provide assistance that will be responsive.

I also want to take a moment this morning to express my personal concern over the action taken yesterday by the House Subcommittee on Science, Research and Technology in its markup of the NSF authorization. That subcommittee yesterday cut the NSF budget request for basic and applied research by $43 million.

In other action, the subcommittee voted to cut off all funding for the Science for Citizens Program and to cut funding for continuing education from $1.2 million to $600,000.

The bill will be voted on by the full House Committee on Science and Technology next Wednesday. I would urge all of you—who support a continuing Federal commitment to scientific research, and who believe that citizen participation is the key to building wide public support for that research—to make every effort to make your views known to the House Science and Technology Committee during the next few days.

Our first panel this morning consists of represenatives of the academic community. Many of the groups they represent, particularly the American Association of State Colleges and Universities, played a very important role in the effort to insure that the NSF remained under the jurisdiction of our committee—a committee which has a long record of commitment to education and the needs of the academic community.

The panel this morning consists of Wesley W. Posvar, chancellor, University of Pittsburgh, Pittsburgh, Pa.; T. R. Williams, professor of chemistry, College of Wooster, Wooster, Ohio; Lillie K. Singleton, institute associate, Institute of Higher Education Research and Services, University of Alabama; and William Jackson, professor of chemistry, Howard University, Washington, D.C.

Before we ask Dr. Posvar to begin, I will ask Senator Schweiker for any opening comments.

Senator SCHWEIKER. Thank you, Mr. Chairman.

I would just like to present to the committee one of my constituents who was just mentioned a moment ago, the chancellor of the University of Pittsburgh, Dr. Posvar.

This is the 10th year Dr. Posvar has been chancellor of the University of Pittsburgh. He has five earned academic degrees; one from West Point; two from Oxford where he was a Rhodes Scholar; and two from Harvard University; a MPA and a Ph. D. in political science. Dr. Posvar is a trustee of the Carnegie Endowment for International Peace, and the Rand Corp. He is a member of the Council on Foreign Relations and the International Institute for Strategic Studies. He is also a past president of the Pennsylvania Association of Colleges and Universities.

I think he has a very unique background academically and, no doubt, that is why the University of Pittsburgh has risen to new heights under his leadership.

I have known him for a number of years and admire and respect his leadership.

I am delighted to have Dr. Posvar here with us today.

Senator KENNEDY. Proceed.

STATEMENT OF WESLEY W. POSVAR, CHANCELLOR, UNIVERSITY OF PITTSBURGH, PITTSBURGH, PA., ON BEHALF OF THE ASSOCIATION OF AMERICAN UNIVERSITIES, AMERICAN COUNCIL ON EDUCATION, AND NATIONAL ASSOCIATION OF STATE UNIVERSITIES AND LAND GRANT COLLEGES; ACCOMPANIED BY T. R. WILLIAMS, PROFESSOR OF CHEMISTRY, COLLEGE OF WOOSTER, WOOSTER, OHIO, ON BEHALF OF GREAT LAKES COLLEGES ASSOCIATION, ASSOCIATED COLLEGES OF THE MIDWEST, AMERICAN ASSOCIATION OF STATE COLLEGES AND UNIVERSITIES, AND NATIONAL ASSOCIATION OF INDEPENDENT COLLEGES AND UNIVERSITIES; LILLIE K. SINGLETON, INSTITUTE ASSOCIATE, INSTITUTE OF HIGHER EDUCATION RESEARCH AND SERVICES, UNIVERSITY OF ALABAMA, ON BEHALF OF THE AMERICAN ASSOCIATION OF JUNIOR COLLEGES; AND WILLIAM JACKSON, PROFESSOR OF CHEMISTRY, HOWARD UNIVERSITY, WASHINGTON, D.C., ON BEHALF OF THE NATIONAL ORGANIZATION FOR THE PROFESSIONAL ADVANCEMENT OF BLACK CHEMISTS AND CHEMICAL ENGINEERS, A PANEL

Dr. POSVAR. Gentlemen, I have an awesome constituency. I am speaking in behalf of the Association of American Universities, the National Association of State Universities and Land Grant Colleges, and the American Council on Education.

While I will enunciate broad principles and ideas that I am sure represent the views of most of the members, obviously one person cannot speak for all the other individuals who are members of those organizations. I shall do my best.

First of all, I would like to say that we are all very gratified at the increases that the last administration and the new administration support for the National Science Foundation budget; and we hope, indeed, as Senator Kennedy indicated, that we will preserve this budget against cuts made in the House and that we will be able to move ahead.

We have been through some very difficult times in higher education in our defense of technology and research. As we all know, in the past period of 10 years or so, we have been subject to a lot of questioning, criticism, and I think some of this has been constructive. Some has been very good for us, because we have begun to learn that we have to explain ourselves and our needs better, and higher education and research are indeed part of the national interest, and not just the self-interest of scholars.

I think some of the points made by Senator Kennedy about citizen testing objectivity of benefits of research are highly relevant to that comment. As we all know, because of the criticism of past years, in constant dollars the Nation's basic research investment has dropped 20 percent, along with the NSF budget.

This new budget and last year's represented a slight turn upward, a slight reversal, but the new budget presented involves only a 3-percent net increase in true dollars for basic research.

We urge this as an absolute minimum.

Mr. Chairman, I would mention that I am giving an oral presentation, and there will be a text, an amplified text furnished within the near future, elaborating upon these points. I am going to stress education——

Senator KENNEDY. Doctor, before you leave that, you made a comment about funding for basic research.

What do you think a cut of the magnitude of $33 million, given the decline in support in constant dollars over the last 10 years. Without getting into the details, because it just happened yesterday, what would this mean given the needs which you understand exist and their importance to our national interest?

Would you like to make a comment on that?

Dr. POSVAR. Well, I think it is both very distressing and very mysterious because basic research has a tremendous multiplier effect as funded by the Federal Government on universities; a multiplier effect on all R. & D. in industry and on industrial growth and all of technology, and, in turn, on all of our progress.

The distressing thing about the $33 million is that it is the money at the margin. Because of the commitments and overhead of existing programs, the items that will be cut in that $33 million will be the new programs, will be the new ideas that are coming on line this year. The young investigators and their proposals will be wiped out.

It is the worst possible way for this country to save $33 million that I can imagine.

Senator Kennedy. Then it is not that this money cannot be expended wisely. There are a few programs perhaps that, at the urging of the public, we have tried to resolve by throwing money at them. We have seen some of that in law enforcement assistance. We have spent enormous amounts over the period of the last 8 or 9 years, and we have not accomplished very much.

There may be other examples. As I understand what you are saying, it is that the needs are there and the potential for constructive research is there. You believe that there is meritorious work to be done, in both the industrial and academic sectors.

Dr. POSVAR. Absolutely.

I would put this in a completely different class of public investment than, say, directing dollars at social problems.

Obviously, you cannot do a cost-benefit analysis of a given basic research program in, let us say, cell biology. Most of such programs probably will not pay off—one will. Out of those discoveries that will come along in future years will be the breakthroughs in life sciences, physical sciences, production of new energy, and so on.

So, short-term cost-benefit analysis will not work.

In the long term, research is the strongest cost-benefit argument that you can possibly imagine because it is the only way to progress in the long-term future of this country.

I will stress, as I said, education, and I will also say something about the problem of administration within universities, the need for flexible funds, and the difficulty of the present so-called project system of research support.

Let me skim over some background.

We have been through the great debate about applications, and I think this was just alluded to by Senator Kennedy. How do we justify research?

Well, NSF has accommodated with the program of research applied to national needs. We endorse this program. We think it is a good complement to pure basic research, and within this budget, you will see some very good programs of application: earthquake engineering, weather modification, research for nonconvention food sources.

I think these do have a complementary relationship to basic research.

But the fundamental case remains. The main case, I think, was stated very well in a document issued by OMB in January of this year, and we would like to support this. The points are essentital:

Basic research is important to economic growth in the solution of national problems.

Another point, normal economic incentives will not in themselves produce an adequate volume of basic research.

Another point, the lag between discovery and application is so long and unpredictable that only Government in our society can feasibly provide the necessary support. In other words, the horizons of industry are inherently too short to make this kind of investment.

And, of course, the Federal agencies do need and do benefit from basic research in order to do their missions.

I think that we can go further, as I did a moment ago, and say that basic research is the key multiplier to economic development and; in turn, to the development of our whole society, the future of our society, and the NSF budget and how it relates to higher education and research, I think, is the central part—it is a very, very small part, but it is the central part of this kind of national investment.

Let me give some examples, just looking at my own university. We have over $3 million of NSF funding at Pittsburgh. I looked over the list of our programs last night. There is a wide range of programs, very exciting programs, many of which I do not begin to understand, but these are the ones that make the difference in cell biology, in studies of atomic particles, nuclear structures, upper atmosphere research, RNA synthesis. Also in applied sociology, study of library management, study of philosophy of science, and even—speaking of quality in human progress—we have an archeological dig near Pittsburgh which has been determined to be the oldest site of continuous human use in the Western Hemisphere, going back about 20,000 years. It is a very important historical discovery. This is being excavated with NSF funds. It is a very, very modest program, $60,000 a year.

It represents an important, a very important development in the archeology and anthropology of the United States. It could not be done—that program simply could not be done—without the NSF.

Senator SCHWEIKER. How much of that is NSF money?

Dr. POSVAR. About $60,000 last year, and $50,000 this year; plus $5,000 or $10,000 here and there from foundations and individuals who have kicked in.

Senator SCHWEIKER. Very interesting program.

Dr. POSVAR. Yes. Exciting place to visit, too. It is really fascinating.

Senator KENNEDY. Where is it?

Dr. POSVAR. It is at Avella, Pa., a small mining town. It is called the Meadowcroft Rock Shelter, an outcropping of rock which was used for a hunting and camping site going back beyond what they originally thought was the time man crossed the Bering Strait.

They have had to change their perception of that.

Senator SCHWEIKER. They are back to how many thousands of years ago?

Dr. POSVAR. Nearly 20,000.

Just a couple of high points in the budget.

Instrumentation: The program speaks for itself. We at the universities are concerned that the Nation's technological competence for instrumentation has been badly eroded. It is obsolescent, and a tremendous catchup effort is needed. Funds required for this are in the budget.

Science education: One favorable development in the House was an increase, although we deplore the cut in basic sciences. They did increase the education budget, and most importantly, they added an increment for education of minorities in science. We enthusiastically endorse that change.

The basic problem in education for science is one of maintaining quality, and maintaining a flow of supply in the future. We went through the market swing whereby we met a short supply, high demand, by training lots of scientists in the 1950's and 1960's, and we are in a state of flux at the present time.

There is a very serious danger of the pendulum swinging back, and the marketplace virtually eliminating the flow of young scientists. The comprehensive assistance for undergraduate science education (CAUSE) program, and the undergraduate instruction improvement program can benefit small colleges, smaller institutions. There is $5 million proposed for this, which we strongly support.

At the graduate level, the graduate fellowships program is vital. Those were held to 500 some years ago, have not increased since. Those should be increased, we think, to a thousand. Every one of those is a tremendous public investment. We think, as other educators have said, that those should be expanded to the humanities and arts as well.

At the next level, postdoctoral fellowships, we think that program is dangerously underfunded in this budget at $2.3 million. We suggest $5 million, and an increase of postdoctorates from 100 to about 250.

Then, at the junior faculty level we urge the advancement of what is called in the budget the research initiation and support program (RIAS). This is a way of helping junior scientists in laboratories, in universities and colleges, to fund their new programs in flexible ways.

There is $4 million in the budget for this. We would suggest at least $10 million.

Again we are not talking about producing an oversupply of scientists. We are talking about a small supply of high quality scientists getting into the pipeline and being the leaders of technology and science in the next generation of America.

If we let the market itself function, that supply could be snuffed out or at least drastically curtailed.

This problem has also been encountered in Western Europe, particularly in Germany. They are doing the kind of things we are recommending.

I would like to mention finally the university as a base for science.

We worry about the practice of the Federal Government in recent years to consider that the Federal Government is merely a client, should not pay the full costs of federally supported research, and should thus make universities divert funds from educational functions and other service functions for research.

When we are underfunded in overhead and forced to contribute hard money to research, we can quickly reach the point where we cannot accept the funds for research. We just simply cannot find the money to do it.

This policy is becoming a deterrent, a massive preventive of basic research, if you will. It would be far better to spread whatever dollars we have to full support for basic research whereever it is done.

In this connection one of our difficulties is the project system, which is fine in itself. This means projects are proposed and funded by the Federal Government on their own merits, but within a given university there may be 100 of these projects, and they are funded in an unrelated way.

We lack flexibility. We lack funds to take up slack when there is underfunding, or when the program is cut off, to keep the investigator going, to put groups of people together for research.

There needs to be some element of institutional funding for institutional flexibility, and a way to orchestrate individual projects and programs.

There was an Institutional Improvement of Science Program. It was terminated in 1975, and we need something like that again in the future.

Let me just conclude, gentlemen, by saying as I indicated before, I think that basic research and with it higher education at all levels are the key to the economic and technological progress of this country. Only that progress can bring increased productivity and increased prosperity, and in turn only that can bring what we all talk so much about: improved quality of life and expanded will-being for all the people in this country.

There is no other way to get there from here than to invest in our future. We are literally concerned in this subject with the welfare of Americans over the coming decades and in the next century.

Thank you.

Senator KENNEDY. We will come back to additional questions. But as I understand it, you are going to present to us item by item priorities?

Dr. POSVAR. Yes.

Senator KENNEDY. One thing I think you ought to address before we move on, and that is a point made by the Appropriations Committee and others that a significant amount of these grants goes to overhead and not as much as one would think goes actually to research. I think you ought to address that issue. Can you put the issue of overhead and administration costs into perspective.

That is an argument we get. I would like to hear what the best answer is.

Dr. POSVAR. There is a short-term limited point of view which says that indirect overhead—that is, the kind of expenses that universities have to have to be a research institution, libraries, computer centers, laboratory maintenance and so on—that that should not be funded by the Federal Government because a given grant for a given year or two can feasibly be supported without compensating for that. But in the meanwhile, the universities are eating themselves up, the resources get used up, and if that became a policy, we could no longer support the libraries and computer centers and the laboratories—and the basic research would quickly disappear.

We should not, although we have from time to time, and I regret it, taken money from education and from public service to subsidize basic research. In the tight days of the present and the future, we can no longer do that. To deny universities indirect overhead or direct overhead is literally to ask them to transfer funds—to transfer hard money funds from education to basic research. We cannot do that morally, and we cannot do it logically. So if research is to continue in the long term, the whole cost has to be borne by supporting agencies, and I think that means ultimately the public of the United States through the Federal Government.

[The prepared statement of Dr. Posvar follows:]

Testimony on the Proposed

Budget for the National Science

Foundation for Fiscal Year 1978

before the

Subcommittee on Health and Scientific Research

of the

Committee on Labor and Public Welfare

United States Senate

by

Wesley W. Posvar
Chancellor
University of Pittsburgh

on behalf of the

American Council on Education
Association of American Universities
and
National Association of State Universities
and Land-Grant Colleges

March 3, 1977

Mr. Chairman and members of the Committee:

My name is Wesley W. Posvar and I am Chancellor of the University of Pittsburgh. My testimony is on behalf of the Association of American Universities, the National Association of State Universities and Land-Grant Colleges, and the American Council on Education. The member institutions of these organizations perform practically all of the academic research and related graduate training in the country, as well as most of the undergraduate education. While neither these associations nor I as an individual can speak for all of their members, I can present to you certain broad conclusions about the budget of the National Science Foundation that I am sure virtually all members would support.

We are gratified indeed that both the outgoing administration and the new administration have seen fit to recommend important increases in the budget for the National Science Foundation, and we hope that this committee will recommend authorization of at least the amounts proposed. In recent years government support of basic research has declined at least twenty percent in real terms, suggesting a misunderstanding about the true value of facilitating scientific and technological research. The recommended net increase of about eleven percent in the NSF budget for FY 78 reduces to about three percent in constant dollars, but even so it is an actual increase and represents an important reversal of the past downward trend.

I am especially alarmed by the possibility of the House of Representatives' making large cuts in the basic research portion of this budget. Any reductions would be deeply harmful. They would affect that margin which can give innovation and quality to our scientific investigation, especially the new programs, and thus they would slow down forward movement in the nation's research as a whole.

The urgent need to reverse the downward trend in funding of basic research in the Federal budget suggests a need for all of us in higher education to better explain our research programs and their value to society. I would stress that basic research performed in institutions of higher education is the best possible investment this country could make in its future. We must get across to Congress and the public the point that in this area the interest of higher education is in itself vital to the national interest and that its basic research is eminently worthy of public financial support.

Within the context of general strong support for the NSF budget, which I shall spell out, I shall also stress two areas of pervasive concern. One is the need to provide stronger financial support for small-scale scientific research, or programs that are in smaller institutions, as well as for expanded science education in the undergraduate level. We are pleased with proposals to expand funding in these areas, and in particular those that would expand opportunities for minority persons.

The second concern is a lack of government appreciation and support of the whole system of basic research at the university. We especially deplore any proposed Federal policy of not reimbursing full direct and indirect audited overhead costs. This means that part of the cost of research has to be offset by reductions in established educational and service programs. The only possible long-term consequence of such a policy is to discourage basic research or even preclude it. Another aspect of our concern is the Federal stress on the "project" system of research support, whereby many individual projects are funded, often in erratic and uncoordinated ways, while the institution itself is not allowed the opportunity to relate projects to one another and to sustain them as part of a long-term coherent institutional effort.

Research Related to National Needs

In recent times there has been serious debate about whether the National Science Foundation and other government agencies should emphasize support of research programs more directly and immediately related to identifiable national problems. We believe that the National Science Foundation has worked out a generally suitable blend of support for basic research and research which is directed toward stated objectives. In the latter category, important programs receiving support include those in earthquake engineering, weather modification, and the identification and development of nonconventional food sources. We accept the fact that there is a complementary relationship between basic research and problem-oriented research, and we endorse the concept of relating these as now done by the NSF.

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Expansion of Basic Research Support

The changed attitude of the Office of Management and Budget towards the role of the Federal government in aiding basic research is made clear in this important statement: "The Federal government has a key responsibility in assuring an adequate level of National support for basic research." (Issues '78, Office of Management and Budget, January 17, 1977)

In our view, the reasons cited for this position by OMB are directly on target:

- Basic research is important to economic growth and the solution of important national problems.

- Normal economic incentives will not produce an adequate volume of basic research.

- The lag between discovery and application is so long and unpredictable that only government can supply the necessary support.

- Mission oriented Federal agencies need the products of basic research to carry out their tasks well.

One of the major defects in national science policy has been vacillation in attitudes towards the responsibility of the Federal government for basic research. It would be helpful if this Committee would see fit to reiterate the policy position stated by OMB. The Nation would be strengthened if these principles were to become a continuing base for the specific actions of the Executive and Legislative branches with respect not only to the NSF basic research budget but also to the basic research budgets of all major Federal agencies.

In considering the amount of the increase requested by the President for basic research in the NSF budget, we suggest that the Committee bear in mind a central fact mentioned earlier--that we are just emerging from a period of years during which there were cuts in the total basic research program of the nation, measured in constant dollars.

Again, I acknowledge that some responsibility for this falls upon educators and scientists themselves, for not adequately explaining themselves, their aspirations, and their needs as essential contributors to national progress. I stress that basic research is the cutting edge of progress; higher education, in comparison with industry, performs a small but highly creative and objective role, and those programs supported by the NSF are the driving element in the best of our basic research.

As I look across the array of programs supported by the NSF in my own university, I see item after item, many of which I do not have the technical knowledge to explain, but which I know are bringing important, original contributions to human knowledge. Among these are studies in cell biology, collision of atomic particles, ionization of the upper atmosphere, nuclear structure and reactions, RNA synthesis, and many others in the fields of chemistry, biochemistry, physics, crystallography, astronomy, and so on. NSF funds this year at my institution also support an important study on how libraries may be used more efficiently, and studies in applied sociology, the philosophy of science (such as irrationality in empirical scientific investigations), and even archaeology--at Meadowcroft, near Pittsburgh, we are excavating a rock shelter that is the oldest site continually used by humans yet discovered in the western hemisphere, about twenty thousand years old. It has revised basic theories of when man crossed the Bering Strait and migrated eastward. This project, so important to our knowledge of the earliest Americans, would not have developed and cannot go on without NSF support.

Instrumentation

I especially call your attention to the substantial increases proposed for instrumentation. One third of the total $87 million increase proposed in the NSF budget, or $28 million, is for instruments. In our view, this proposed increase is badly needed. During the 60's the laboratories of the nation were splendidly instrumented, and this had much to do with our then increasing preeminence in science. The view developed, however, that since the laboratories were fully equipped, the scale of support could drop. Between 1966 and 1976, the proportion of NSF project grant funds allocated for permanent equipment dropped from about 11 to about 5 percent. Since funds for equipment from other sources dropped at the same time, the quality of instrumentation in university laboratories has declined sharply, and the installation of large facilities required to work on the frontiers of many branches of science has lagged. Even our best-equipped laboratories have become subject to "creeping obsolescence."

All recent studies of the health of science in this country have reported that the deterioration of instrumentation is a major threat to the continuing productivity of basic research. This is a major conclusion of the recent report of the National Science Board, Science at the Bicentennial--A Report from the Science Community. Quite independently, a recent study of the health and future of academic science conducted by Professor Bruce Smith and Professor Joseph Karlesky under the auspices of the Association of American Universities showed clearly that deterioration of scientific equipment is of enormous concern to the scientists of the nation. This study, which was financed by the National Science Foundation, will appear in book form in April.

We strongly urge the Committee to authorize the funds to permit the upgrading of instrumentation, as provided for in the President's budget.

Science Education

The Administration had originally proposed a very modest increase in the budget for science education, and we are encouraged by the possibility that this funding level may be increased, especially in the area of education for minority students and opportunities for minority scientists. We are also very much in favor of the proposed $5 million increase for undergraduate education in the program called Comprehensive Assistance to Undergraduate Science Education (CAUSE) and in the Undergraduate Instruction Improvement Program.

Looking beyond these programs, we are deeply concerned about the future supply of scientists and engineers to keep this nation on the advance in science and technology.

For almost three decades following 1940, we became accustomed to demands for highly trained scientists and engineers that far outstripped the supply of such people. Then the situation changed dramatically, and for a few years there appeared to be a surplus in scientists and engineers. If we continue to follow such up and down market indicators, we shall be unable to maintain an increasing and steady supply of highly qualified scientists and engineers for our long-term future.

We therefore strongly support a comprehensive program of fostering such a supply. We feel this can be done through supporting and expanding three programs, at three levels, that are already in place.

At the first level, we have the graduate fellowship program, which has been held for years at an annual level of five hundred. We favor an increase to one thousand, which is still modest in terms of the whole nation. This kind of fellowship should also be expanded to other fields, and we specifically support the recommendations of the National Board on Graduate Education that there be one thousand fellowships per year in the arts and humanities as well as one thousand in science and technology.

The second element--post-doctoral fellowships--is also in place. In concept, such post-doctoral support will help ensure that a small number of the most competent recent Ph.D.s remain in academic science under conditions best designed to ensure their intellectual growth. Further, we believe that post-doctoral fellows, like those selected for graduate fellowships, should receive awards directly and work where they find the most stimulating opportunities. Post-doctoral research opportunities are provided under many Federally supported research grants and contracts, but it is highly desirable that these positions be supplemented by the freedom of choice that is available under a fellowship program. There are, of course, advantages to tying some post-doctoral positions to established research programs and teams, so we believe support of post-doctoral work under research grants and contracts should continue. We feel, however, that at the proposed level of $2.3 million, the existing post-doctoral fellowship program is underfunded. An increase to $5 million, which we support, would provide for approximately 250 fellowships per year as contrasted with the current level of approximately 100.

At the third level is the new (1975) Research Initiation and Support Program (RIAS). The purpose of this program is to increase research opportunities for younger scientists by awarding them grants for exploratory research, equipment, and related needs. In the first year of funding, awards approximating $4 million were made to 19 colleges and universities, while there were 261 applications totaling $59 million. An expansion of RIAS would enable it to serve more effectively as a component of an integrated program. We therefore recommend that funding be increased to $10 million. In a few years it may be necessary to support salaries for some younger faculty members to attract the best of the current crop of students to academic careers of research and teaching. The RIAS program could be modified to provide such support.

While this proposed three part approach may not provide the optimum formula, we suggest that for the time being it supplies an explicit unifying rationale for the post-baccalaureate support programs of NSF. These programs recognize the need to sustain a limited number of teaching and research openings for a rigorously selected group of younger scientists and engineers who can provide leadership into the next generation.

It is worthy of note that this problem of sustaining a flow of younger faculty into the advanced educational system has been recognized in Western Europe also. The government of West Germany IS PROPOSING [redacted] what is called the Heisenberg program, which would carry a limited number of highly selected students through graduate work, a post-doctoral period, and into junior faculty positions. Under the Heisenberg program, the government would deliberately augment university budgets to provide salaries for younger scientist-teachers.

As a special aspect of the NSF education program, we fully support efforts to increase the participation of minority persons in science and engineering careers. We are aware of the complexities which accompany this objective, and feel it is important to consult widely, especially with knowledgeable and experienced members of minority groups, before committing funds to specific programs.

Sustaining the System of Basic Research in the University

It is a fact not often enough recognized that the American economic system, in an approach that is unique in the world, has supported much of its basic research through the Federal government. Further, much of the most open and creative basic research is in laboratories within or related to universities. This has been a key to our technological advancement in this century, and in particular in the last several decades.

An important feature of the Federal-university relationship is that over the long run, the capacity of universities to do what they are particularly good at--basic research--depends upon their overall strength and their flexibility. As costs rise and as university income becomes more and more linked to mere survival, we also lose the capacity to finance exploratory ventures, to support the early research efforts of young investigators, and to cushion research efforts from the disrupting effects of short-term financing.

Moreover, a dangerous doctrine has been advanced--that the Federal government has no responsibility to keep the university research base healthy and flexible, the assumption being that universities are merely entities which the university can contract with to produce research it wants.

This feeling is harmful to both the universities and the nation. When the Federal government does not pay the full costs of Federally supported research, including direct and indirect overhead, universities must divert funds from educational and public service functions to cover the research costs not met by the government.

This is possible only in the short run; in the long run, if permitted, it would discourage such university basic research and eventually eliminate it.

There is a serious weakness in the method of support for academic science, in that it is essentially a "project" system. This means that grant applications are judged in national competition and awards are made on the advice of peers for the most promising proposals from individuals. This system has certain merits and has led to excellent work but also has one glaring defect: each project is considered in isolation, not as part of a coordinated whole. A large university has hundreds of these projects. It is difficult to insure that the combined effects of all of them are taken into account.

Universities need resources to cushion research programs against the random effects of project terminations and changes in expenditure rules. Moreover, investigators must be nurtured as they develop, skilled technicians must be kept at work (to maintain their skills) regardless of fluctuations in budget, and facilities must be built and supported for varieties of research projects. Exploitation of new ideas and radical shifts in lines of investigation may require that funds be provided much more quickly than possible under the project system.

For many years the National Science Foundation provided institutional grants for related purposes under the Institutional Improvement of Science Program (IISP), but this program was terminated in 1975. (The Office of Management and Budget has repeatedly advocated that similar grants made by the National Institutes of Health be abolished, but the authorizing and appropriating committees have repeatedly reinstated the grants.) We feel that the abolition of the NSF Institutional Improvement for Science Program reflects an incorrect government view on research support in institutions of higher education. We must continue to undertake to persuade both Congress and the Executive Branch of the wisdom of reinstituting the kind of grant that would meet the need for flexible research funds. The amount of money required for such flexibility would be very small in relation to the total research support effort involved, and would be the best of public investments.

Conclusion

Mr. Chairman, I would like to conclude and summarize by making these simple observations:

Support of basic scientific and technological research and development is the main investment that can contribute to the economic progress and prosperity of our society. In that effort, the kind of research that occurs in the environment of higher education is of small scale but central.

Only this kind of progress in our research programs can bring the much needed increase in productivity and prosperity in this nation. Science, as well as higher education in general, must provide the increased understanding and control of our environment which can foster the improved quality of life and well-being to which we all aspire and which will make feasible the achievement of our highest social goals.

The welfare of Americans in the coming decades and in the next century is inherently involved in the issues we discuss here today. We therefore insist that the National Science Foundation, and its support of higher education and basic research, are a vital national investment.

Thank you for giving me the opportunity to express my views before you today, on behalf of all those whom I represent.

Senator KENNEDY. We will continue along and come back on this. Dr. Williams.

Dr. WILLIAMS. I thank you for giving me the opportunity to talk on the bahalf of the NSF fiscal budget for 1978.

I am a professor of chemistry at the College of Wooster in Ohio, and I am speaking for the 25 independent colleges and universities in the Great Lakes Colleges Association and the Associated Colleges of the Midwest, and 324 member colleges of the American Association of State Colleges and Universities and the 631 members of the new and growing National Association of Independent Colleges and Universities.

Now obviously I cannot speak completely for all of them, but I will try to reflect their views.

I have a prepared text, and when you want to stop me at some point, please feel free to do so.

I believe that the undergraduate institutions I speak for have a significance often overlooked in NSF priorities. Even in numbers some smaller schools hold their own in production of science majors. While the majority of scientists graduate from the larger universities, in terms of percentages and absolute numbers some large universities have not produced science majors commensurate with their enrollments.

I have a table of information here which looks at baccalaureate degrees in chemistry from four Ohio schools: Ohio State University, Ohio University, Oberlin College and College of Wooster.

If you look at 1976, you see that Ohio State had 9 chemistry majors; Ohio University had 18; Oberlin College, 24; and College of Wooster had 24. This came from the American Chemical Society Annual Report, and we must be careful not to extrapolate the figures, but the point I want to make here is that one must realize that some undergraduate institutions have been a high supplier of scientists in the past.

Now let's look at science education and science research budget requests. The National Science Foundation budget request for fiscal 1978 makes a clear distinction between what the agency sees as the need for support to science education and the need for support to research. The budget asks for $688.1 million for basic research and only $75.7 million for science education. This is unfortunate since research and education go hand in hand.

At the undergraduate level, the emphasis on science is on course work and to a lesser extent on research. At the graduate level this proportion is reversed. Even pure scientific research depends on well-educated scientists. Funds for science education must be significantly greater than the 10 percent of research expenditures NSF has requested for fiscal 1978. We recommend a target ratio of one-third. We support Dr. Posvar's statement and agree that neither education nor research should be funded at the expense of the other.

NSF's long-term record of promoting excellent undergraduate education is outstanding. By allotting small grants to undergraduate colleges for instructional equipment and summer research programs especially, NSF has been able to plant the seeds of research in those institutions. Students in many colleges are now able to use sophisticated equipment as a part of their early training in a way that was not possible 20 years ago.

To my knowledge, NSF has been the only source of funds for such wide basic training in the undergraduate sciences in this country. This NSF role in improving undergraduate education is responsible in the main for the high quality of science education in our Nation today.

We are concerned that certain bills before Congress would put science education programs under different control. The proposed transfer of the science education programs out of NSF to a new department would fragment the total science effort and, we believe, might well reduce the quality of that effort. The present structure of NSF provides the necessary framework for the continuum of science. Both science education and scientific research are implicit to the total.

We believe that the present imbalance between support for research and education is improper. This should not be interpreted to mean that we are critical of the quantity of funds flowing to research. We commend this use of resources, providing some balance with science education is restored.

However, we would suggest serious consideration of an earmarking of funds within the basic research budget to support "little science." Perhaps the most exciting research is by definition big. It requires teams of researchers, masses of costly equipment and huge quantities of dollars. Big science can be accommodated only at Government research centers, in industry or on large university campuses.

Senator KENNEDY. Are you talking about new technology or basic research?

Dr. WILLIAMS. In the big grants the way we do it today is with a team of five or six people or more for molecular biology, for instance. The big synthetic things may require 12 post doctoral people, and the equipment is very expensive.

There is another side of science in basic research. One or two researchers working as a small team can make a contribution also, in our opinion. We want to fund those people enough so that we get movement of ideas not only from big research programs, but also from smaller research programs.

Senator SCHWEIKER. How much of that is going on now? In other words, is your point that not enough of it is going on now, or have the small teams not really been given a chance?

Dr. WILLIAMS. I guess my point is that when the budget crunch comes, we give fewer and fewer dollars to small or little research, and this means that it is hard to get started, fresh out of school. Most of the individuals do not want big equipment, and they just do not get funded.

I think we get a reduction in the number of people doing competent work because the funds are not available. There is some but not nearly as much as there should be in my opinion.

Senator SCHWEIKER. Is this because of the size involved here and/or the needed expensive equipment to do that research?

Dr. WILLIAMS. I do not think it is a matter of size. There are a variety of different ways to do research. We do research in our small college, and I think it is not to be compared in size with big research groups, but I think we need just a little bit of money to get that going.

So I think in NSF's budget crunch they support bigger programs rather than the small ones—something has to give, and I think by and large we are the groups that have been giving.

Does that answer your question?

It is easy for equally important, if less dramatic, "little science" to be downplayed or even ignored. I have seen examples where a small team comes along with some fairly sophisticated ideas. They have to be more creative in many of the cases.

Senator KENNEDY. Are you suggesting there is sort of inherent bias in terms of peer review in NSF against small science or unknown or younger science researchers? That has been suggested.

Dr. WILLIAMS. I will say the people who do the reviewing in many cases turn out to be people from big science. We would recommend more and more people from little science, those in non-Ph. D. degree granting programs, be a part of the review process.

I think it is important to get a full scope of representation in these efforts.

Senator KENNEDY. In other words, the peer review process itself does not have representation of the little science you were talking about?

Dr. WILLIAMS. Especially at the basic research level.

Senator KENNEDY. I suppose it reaches another point, too. It is a good deal safer to give grants to a major university with well known people. The people at NSF are not going to get themselves in much trouble if they stamp OK on those grants. But if they found small science, the younger or less known people, and the thing does not pan out they may be more subject to criticism. Are there not some inherent pressures in that respect of the peer review process?

Dr. WILLIAMS. Things have changed dramatically. About 10 years ago many of the bright minds sort of moved around a very closed circle, a very closed circle. They would move from one big school to another.

This is no longer the case. People who are very competent, in fact, one of my very best former students, who probably holds the record for publication at Harvard, now is at a smaller school, and is quite a productive individual.

We want to fund those people, and in other words, increase the broad base of support. It may not be as safe, risk-free, but I think it is important to do this.

I think one of the things we have to realize is that there are different prices or cost requirements for different research programs. In physics we obviously need quite a bit of complex equipment. In social sciences, we need smaller amounts of money.

What we need to do is look at particular disciplines and develop some guidelines or formulas as to what we allot for small grants. We should lay aside some moneys for small research in all areas.

We might consider, say, solid state physics, and we ask for maybe 20 percent of the money to go into grants of roughly $35,000 or less.

Now in social sciences, you find it is a little bit cheaper to do research, and we might up that margin to a larger percentage so that we can fund broader base of people.

NSF has been very good with big instrumentation work. It has really done a tremendous job. But there should be some attempt to eventually remove the present floor on equipment.

The point I am trying to make is that they tend to support the purchase of costly, big equipment and not the purchase of smaller equipment.

We would suggest you in Congress set aside some funds for equipment for little science research projects. Let us say we would like to have no less than 15 percent of the total instrumentation budget set aside for grants of, let us say, $25,000 or less, and can really get started quite well in a little science program.

I would like to turn next to the whole problem of NSF science education. My experience with NSF grants has been related to instructional scientific equipment program (ISEP) grants, comprehensive assistance to undergraduate science education (CAUSE) and its predecessor, the college science improvement program (COSIP), and a 17-year involvement with the undergraduate research participation (URP) program—all science education programs.

The URP program has sparked the research of Wooster's chemistry department. Our Wooster 10-week summer program is one in which the student is financially supported and the faculty member gives his time and energy to introduce the undergraduate to scientific research. While the goal of this program is not publication, in our department at least one research paper is published every year as a result of the URP program.

In fact I checked the records after I wrote this and probably two or three papers a year are published by the students. In my view, we must really work to support the URP program. I think the cutbacks would be disastrous.

I would like to speak of the value of this program quite apart from producing scientists. I think nothing, nothing explains science better than having to go into the lab and do something. It takes it out of the realm of the textbook kind of thing.

I think it is important to have a hands-on approach to research and URP provides this.

The fact that 746 proposals were submitted this year, and probably there will be only 181 grants, suggests that other scientists agree with us in this area. We hope that we can increase the role of URP funding to $5 million in the budget.

I think it is imperative to do this.

We note that the new minority centers for graduate education preclude all but Ph. D. granting institutions. We feel we could broaden and attract more students if the master's programs were also included.

We have included here a table which summarizes certain NSF education programs and budget requests. As you see, alongside that is our suggested funding. We do not have to go over this, but if you want to ask me about any of those, I will be happy to comment further.

Thank you for allowing me to come and talk before you. I hope the support of NSF education programs, which has been outstanding by this subcommittee, will continue.

Senator KENNEDY. Very helpful testimony. We will look over these figures and study them and probably be back in touch with you on this.

[The prepared statement of Dr. Williams follows:]

Statement by

Dr. T.R. Williams

Professor of Chemistry

The College of Wooster

On Behalf of

The American Association of State Colleges and Universities

The Associated Colleges of the Midwest

The Great Lakes Colleges Association

and

The National Association of Independent Colleges and Universities

Before the

Subcommittee on Health and Scientific Research

Committee on Human Resources

U.S. Senate

March 3, 1977

Senator Kennedy and Members of the Subcommittee:

Thank you for giving me the chance to appear before you to testify on the National Science Foundation budget for Fiscal 1978. I am T.R. Williams, professor of Chemistry at the College of Wooster in Ohio, and I am speaking for the twenty-five independent colleges and universities in the Great Lakes Colleges Association and the Associated Colleges of the Midwest, the 324 member colleges of the American Association of State Colleges and Universities and the 631 members of the new and growing National Association of Independent Colleges and Universities.

We believe that the undergraduate institutions I speak for have a significance often overlooked in NSF priorities. Even in numbers some smaller schools hold their own in production of science majors. While the majority of scientists graduate from the larger universities, in terms of percentages and absolute numbers some large universities have not produced science majors commensurate with their enrollments. A cursory study of chemistry majors graduating from four Ohio colleges and universities shows:

Number of Baccalaureate Chemistry Majors Graduating

Institution	1976	1972	1968
Ohio State University	9	17	34
Ohio University	18	9	18
Oberlin College	24	14	34
College of Wooster	24	18	30

This information was obtained from the Annual Report of the American Chemical Society on the productivity of chemistry majors at these institutions. One must be careful not to extrapolate the figures, but they do indicate that some undergraduate institutions have been a disproportionately large source of scientists.

Science Education and Science Research Budget Requests:

The National Science Foundation budget request for Fiscal 1978 makes a clear distinction between what the agency sees as the need for support to science education and the need for support to research. The budget asks for $688.1 million for basic research and only $75.7 million for science education. This is unfortunate since research and education go hand in hand. At the undergraduate level, the emphasis on science is on course work and to a lesser extent on research. At the graduate level this proportion is reversed. Even pure scientific research depends on well-educated scientists. Funds for science education must be significantly greater than the 10 percent of research expenditures NSF has requested for Fiscal 1978. (See Appendix A.) We recommend a target ratio of one-third. We support Dr. Posvar's statement and agree that neither education nor research should be funded at the expense of the other.

NSF's long-term record of promoting excellent undergraduate education is outstanding. By alloting small grants to undergraduate colleges for instructional equipment and summer research programs especially, NSF has been able to plant the seeds of research in those institutions. Students in many colleges are now able to use sophisticated equipment as a part of their early training in a way that was not possible twenty years ago. To my knowledge, NSF has been the only source of funds for such wide basic training in the undergraduate sciences in this country. This NSF role in improving undergraduate education is responsible in the main for the high quality of science education in our nation today.

Science Education as Part of Science Continuum:

We are concerned that certain bills before Congress would put science education programs under different control. The proposed transfer of the science education programs out of NSF to a new Department of Education would fragment the total science effort and, we believe, might well reduce the quality of that effort. The present structure of NSF provides the necessary framework for the continuum of science. Both science education and scientific research are implicit to the total.

We believe that the present imbalance between support for research and education is improper. This should not be interpreted to mean that we are critical of the quantity of funds flowing to research. We commend this use of resources, providing some balance with science education is restored.

"Little Science" Support:

However, we would suggest serious consideration of an earmarking of funds within the basic research budget to support "little science." Perhaps the most exciting research is by definition big. It requires teams of researchers, masses of costly equipment and huge quantities of dollars. Big science can be accommodated only at government research centers, in industry or on large university campuses. It is easy for equally important (if less dramatic) "little science" to be downplayed or even ignored. Many important discoveries, however, have come from "little science" -- carried out by a single researcher, with modest equipment needs and an equally modest budget. "Little science" researchers reside on college and university campuses of all sizes, all over the country, concentrated more in some disciplines than in others but with great potential to make important contributions to new scientific knowledge.

To insure that some funding is available for such research, we urge the Congress to earmark a percentage of NSF basic research funds in all fields for small research projects. What constitutes small research varies from discipline to discipline. For instance, physics research with its complex equipment needs is likely to be much more expensive than research in the social sciences. We believe that a formula can be developed to guarantee a reasonable

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share of the basic research funds for "little science." For instance, twenty percent of the funds for Solid State Physics might be set aside for projects of $35,000 or less. For Economics research, which is less expensive, a larger percentage could be set aside for research grants of $35,000 or less.

"Little" Instrumentation Grants:

Some instrumentation programs at NSF have a floor on the price of equipment they will help fund. We ask Congress to set aside some of the increase which NSF has requested for instrumentation for research equipment used in "little science." We would suggest no less than fifteen percent of the total instrumentation budget be set aside for equipment grants of $25,000 or below.

We also urge that NSF seek qualified scientists from non-Ph.D.-granting institutions in greater numbers to serve as reviewers for the instrumentation and basic research proposals.

NSF Science Education Programs:

My experience with NSF grants has been related to Instructional Scientific Equipment Program (ISEP) grants, Comprehensive Assistance to Undergraduate Science Education (CAUSE) and its predecessor, the College Science Improvement Program (COSIP), and a seventeen-year involvement with the Undergraduate Research Participation (URP) program -- all Science Education programs. The URP program has sparked the research of Wooster's chemistry department. The Wooster ten-week summer program is one in which the student is financially supported and the faculty member gives his time and energy to introduce the undergraduate to scientific research. While the goal of this program is not publication, in our department at least one research paper is published every year as a result of the URP program.

In view of NSF's cutback of URP support in the Fiscal 1978 budget, I would like to speak to the value of the program, a value quite apart from its role in producing scientists. One of our GLCA scientists sums up the feelings of nearly all of us when he says, "We believe that the value of URP has been primarily its educational benefit to the students -- showing them in a way not otherwise possible the methods, frustrations and satisfactions of scientific research." Nothing explains the scientific process so well as the hands-on approach to research that URP provides. The fact that 746 proposals were submitted this year for a probable 181 grants shows that other scientists agree with us. We hope that you will increase the support to the Undergraduate Research Participation program by earmarking $5.0 million in the budget.

We also note that the new Minority Centers for Graduate Education preclude all but Ph.D.-granting institutions. Opening the program to institutions awarding master's degrees would, we believe, assist in attracting a greater number of minority students into graduate education.

We recommend that certain other Science Education programs should be given support that is commensurate with the proven need for them, as follows:

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

Name of Program	NSF FY 1978 Request	AASCU, ACM GLCA, NAICU Request	Previous Program High (Year)
Comprehensive Assistance to Undergraduate Science Education (CAUSE)	14.5 ~~11.0~~	20.0	10.0 ('76) predecessor
Local Course Improvement (LOCI)	3.0	5.0	1.0 ('77)
Instructional Scientific Equipment (ISEP)	3.8	8.0	8.9 ('64)
Faculty Professional Development	2.5	5.0	a. 4.0 ('71) b. 1.3 ('73) predecessors

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

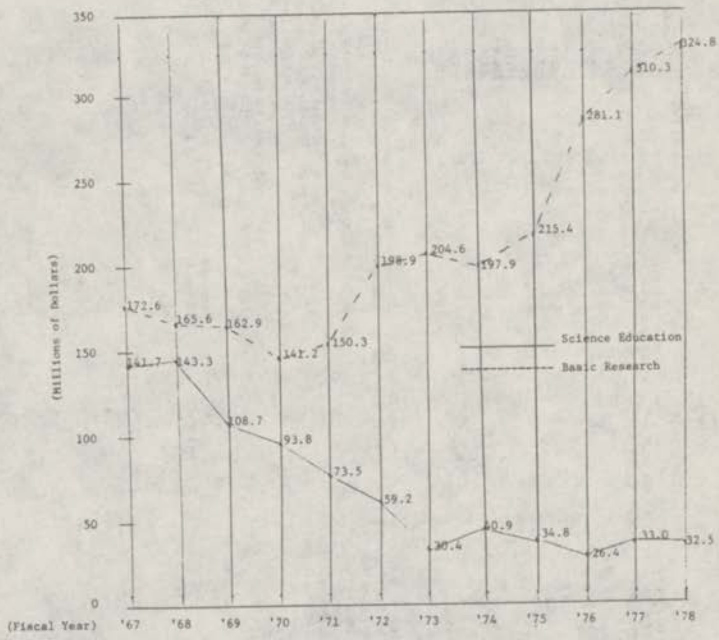
Name of Program	NSF FY 1978 Request	AASCU, ACM GLCA, NAICU Request	Previous Program High (Year)
Undergraduate Research Participation (URP)	2.1	5.0	6.8 ('66)
Student-Originated Studies (SOS)	1.0	2.0	2.0 ('72)
Student Science Training (SSTP)	2.4	3.4	2.4 ('64)
Teacher Training Programs	4.0	15.0	24.3 ('65)
College Faculty Workshops, Short Courses	1.0	5.0	5.5 ('68)

In the interest of saving time, I will not describe each of these programs, but I will be glad to provide further comments either by answers to your questions or for the record.

Thank you very much for hearing our case. We appreciate the strong support this Subcommittee has always provided to science education.

Appendix A

NATIONAL SCIENCE FOUNDATION
Support of Science Education & Basic Research*, FY 1967-1978
In FY '67 Dollars



*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.

Sources: NSF Annual Reports-FY 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975
FY 1978 Budget Estimate to Congress from NSF
Consumer Price Index for Urban Wage Earners & Clerican Workers, Bureau of Labor Statistics, Dept. of Labor
Economic projections of the Council of Economic Advisers, Office of Mgmt. & Budget
Independent Colleges Office 2/77

Independent Colleges Office
February, 1977

SUPPORT OF SCIENCE EDUCATION & BASIC RESEARCH 1/
NATIONAL SCIENCE FOUNDATION
FY 1967-1978 in FY '67 Dollars
(In Millions of Dollars)

Fiscal Year	Calendar Year CPI 2/	A. Fiscal Year CPI Average 3/	B. CPI FY '67 Base=100	C. NSF Budget Expenditure for Science Education	D. Amount Needed to Equal $141.7 M Expended in FY 67 for Educ.	E. Purchasing Power of NSF Education Support in FY '67 Dollars	F. NSF Budget Expenditure for Basic Research	G. Amount Needed to Equal $172.6 M Expen. in FY 67 Bas.Res.	H. Purchasing Power of NSF Basic Research Support in '67 Dollars
'67	97.2-100	98.6	1.00	141.7	141.7	141.7	172.6	172.6	172.6
'68	100.0-104.2	102.1	1.03	147.6	145.9	143.3	170.6	177.8	165.6
'69	104.2-109.8	107.0	1.08	117.4	153.0	108.7	176.0	186.4	162.9
'70	109.8-116.3	113.0	1.14	107.0	161.5	93.8	161.0	196.7	141.2
'71	116.3-121.3	118.8	1.20	88.2	170.0	73.5	180.3	207.1	150.3
'72	121.3-125.3	123.3	1.25	74.0	177.1	59.2	248.6	215.8	198.9
'73	125.3-133.1	129.2	1.31	39.9	145.7	30.4	268.0	226.1	204.6
'74	133.1-147.7	140.4	1.42	58.1	201.2	40.9	281.0	245.1	197.9
'75	147.7-161.2	154.45	1.57	54.7	222.5	34.8	338.1	271.0	215.4
'76	161.2-170.5	165.85	1.68	44.3	238.1	26.4	472.3	290.0	281.1
'77	170.5-179.2	174.85 4/	1.77	58.5 6/	250.8	33.0	549.3 6/	305.5	310.3
'78	179.2-188.9	184.05 5/	1.87	60.7 7/	265.0	32.5	607.4 7/	322.8	324.8

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. (This is done to provide compatible figures.)
2/ CPI=Consumer Price Index (U.S. Department of Labor).
3/ Calculated by averaging two adjacent calendar years.
4/ Projection based on 5.1% inflation (Council of Economic Advisers, OMB).
5/ Projection based on 5.4% inflation (Council of Economic Advisers, OMB).
6/ Current plan.
7/ FY '78 requests.

Sources: NSF Annual Reports-FY 1967, 1968, 1969, 1970, 1971, 1972, 1973, 1974, 1975
FY 1978 Budget Estimate to Congress
Consumer Price Index for Urban Wage Earners & Clerical Workers (1967=100), Bureau of Labor Statistics, U.S. Dept. of Labor
Economic projections of the Council of Economic Advisers, Office of Management and Budget

Independent Colleges Office
February 1977

Senator KENNEDY. Ms. Singleton, we're happy to have you here.

Ms. SINGLETON. Mr. Chairman, I want to thank you for the opportunity to speak at this time. You have before you a copy of the prepared text from which I will speak. I would like to highlight a few of the points that are made in that text.

My name is Lillie King Singleton. Currently I serve as institute associate in the University of Alabama's Institute of Higher Education Research and Services while working toward my doctorate in higher education administration. I am here to present the views of the American Association of Community and Junior Colleges and its member institutions on science education in the 2-year colleges. You may wonder how such a connection develops. I would like to take a moment to elaborate on that.

From 1967 to 1975 I served as chairperson of the Division of Natural Sciences and for part of that time also as director of Federal programs at Lawson State Community College in Birmingham, Ala. Part of my work at the university involves providing services to the State's junior colleges and I hope to be of continued service to Alabama's 2-year colleges when my doctoral work is completed this spring.

I have had considerable experience with NSF science education programs, including the old college science education programs and summer institutes for science students and teachers. I have been a member of the National Science Teachers Association since 1958, and have held several leadership positions in this organization. In 1970–71 I served as president of the Alabama Association of Junior College Science Teachers.

The community and junior colleges and technical institutes on whose behalf I speak are a major force in higher education today. Unfortunately, to date their role has not been recognized adequately in science education awards made by the National Science Foundation.

In his recent testimony before this subcommittee, science education division director Dr. Harvey Averch spoke of his directorate's plans for fiscal 1978. These are designed "to strike a reasonable balance between our responsibility to provide the educational base for our research systems and the need to be responsive to new audiences who have broader, more generalized requirements for science education."

Implied here, I believe, is a response to the concerns that AACJC has been expressing over the years. I hope my statement today can be viewed as a constructive set of suggestions to help NSF reach this goal.

I will make three major recommendations:

First, that for a period of several years, until it has time to have impact, a set-aside for 2-year colleges of 30 percent of program funds should be provided for those programs which support science education at the undergraduate level. Currently these programs include comprehensive assistance to undergraduate science education (CAUSE), local course improvement program (LOCIP), and instructional scientific equipment program (ISEP). If program names are changed or programs are merged, as NSF currently plans, the principle of the set-aside would remain the same.

Second, the Science Education Development and Research Division should be given funds to undertake a needs assessment of science education in 2-year colleges.

Senator KENNEDY. As I understand it, that has not been done?

Ms. SINGLETON. To my knowledge, it has not been done.

Senator KENNEDY. The point is there are other people working in science at these junior colleges. Doing a real review and evaluation of these programs, and how they can be strengthened and supported would be extremely useful as I understand it.

Ms. SINGLETON. Exactly, Senator.

Senator KENNEDY. I do not know why it has not been done. Do you know why?

Ms. SINGLETON. No, I have no idea. But I would again place emphasis on my view, and that of AACJC, that it is indeed something that should be done.

When we look at science programs and, in fact, total programs at junior colleges compared to those of 4-year colleges and universities, we can note significant differences in such areas as the clientele being served, institutional philosophies, educational delivery systems, and in teaching methods used. These and other differences do need to be taken into consideration by NSF as it designs programs and guidelines that address needs that are peculiar to 2-year colleges. So we do feel that the needs assessment study should be done with all haste.

The third recommendation is to correct what appears to be a general inequity in the peer review process. NSF should make sure that a majority of reviewers of proposals from 2-year colleges are themselves 2-year college people. This is the only way we can have true peers doing the reviewing.

I would emphasize again the fact that 2-year colleges are a major force in American higher education. They currently enroll over 4 million students in degree programs. This is about 33 percent of the total undergraduate population in the Nation, and nearly 55 percent of entering freshmen.

Community and junior colleges and technical institutes are the point of first access to postsecondary education of many of the groups that NSF—and Congress—is anxious to serve and draw into scientific careers. Included here are blacks, Mexican Americans, American Indians, women, older students, and low-income persons of all types. By neglecting the needs of the 2-year colleges in science education, the needs of these people are also being neglected.

Women are attending college in dramatically increasing numbers. According to Census Bureau figures, the total undergraduate enrollment of women increased by 45 percent from 1970 to 1975. The 2-year college is attracting an impressive share of these women. Recently published fall 1976 enrollment figures show this. From 1974 to 1976 the number of full-time female students in all institutions increased by 11.3 percent, but in 2-year institutions the increase was 22.4 percent. An almost parallel increase was evidenced for part-time female students. Also, 56 percent of first- and second-year undergraduate students with family incomes under $10,000 attend 2-year colleges.

The support which 2-year colleges receive from NSF is nowhere near a level appropriate to their impact on the education of students in sciences.

For example, RULE (now LOCIP), designed to give teaching faculties the chance to do innovative work in their courses, awarded 6 percent of its grants (4 percent of its funds) to 2-year colleges in fiscal 1976.

In ISEP, 5.2 percent of the grants (3.4 percent of funds) were made to 2-year colleges.

CAUSE, comprehensive undergraduate program assistance, had a set-aside for 2-year colleges in fiscal 1976. And note the difference—28.8 percent of the grants for 22.9 percent of the funds, were made to 2-year colleges. In fiscal 1977 the set-aside was dropped, though Congress directed that the CAUSE emphasis should be on 2-year and 4-year undergraduate institutions. We do not yet know what the story will be for CAUSE awards this year. However, if the portion awarded to 2-year colleges is down significantly, we will feel that an injustice has been done to our colleges and to their students.

I would like to take a look at the NSF budget for a moment. The appropriation for 1977 (including the defaults and carryovers) was $797.9 million. As we know, much of this budget funds research, most of which is carried in university and 4-year colleges. And while not for education as such, it does provide research experience for faculty and students and for the general strength of these institutions.

The 1977 budget for science education is $74.3 million—note that this is less than 10 percent of the total NSF budget.

Another area to which I feel I must speak, and on which I beg your attention, is my concern that NSF has a high track record for rejecting 2-year college proposals. One consequence of this rejection pattern is that 2-year colleges are discouraged from submitting NSF proposals. After all, there has to be some chance for success before it seems worth the effort and the cost expended in developing a proposal. The result is that NSF receives relatively low "proposal pressure" in most programs from 2-year colleges. Ironically, this situation gives a rationale for the lower level of awards to 2-year colleges. I would hope that the subcommittee would see fit to recommend NSF funds that would allow some relief in this area.

Let me close by summarizing the recommendations I have made or to which I have made inferences during this testimony.

First, that a 30 percent set-aside is needed for 2-year colleges in those programs that support undergraduate science education. Currently these are CAUSE, LOCIP, and ISEP.

Second, for 2-year colleges, the concept of "peer" appropriate for proposal review must begin with true peers, those involved in that educational setting. A majority of 2-year college proposal reviewers should be 2-year college people.

Third, NSF should be provided with additional funds to undertake a needs assessment of science education at the 2-year college. This will provide the factual and conceptual basis for the development of NSF science education programs and program requirements better meeting 2-year college needs.

Fourth, among such programs should be one which funds science and engineering technology courses in which 2-year colleges are heavily involved.

Fifth, and finally, NSF should engage in positive outreach to 2-year colleges and other undergraduate institutions which provide science education to a significant proportion of American students. We recognize and appreciate the work that the NSF science education staff is already doing in providing technical assistance to this clientele. However, one clear problem is that the staff apparently cannot afford the travel which would permit more of such activity. A larger travel budget, particularly directed toward informing and encouraging broader participation in NSF programs, would help.

An approach which might be helpful is that adopted by the National Endowment for the Humanities. This is the "consultant grant," low cost and available to a high percentage of applicants. The grant pays for the services of a consultant who is an expert in the field who will help the applicant analyze and improve the course under consideration.

Mr. Chairman, before I close, I want to say to you that Dr. David Matthews, president of the University of Alabama, whom I am certain you remember, asked me to bring you his warm and personal greetings.

I want to thank the chairman and the subcommittee for allowing me the opportunity to bring these recommendations to you. Naturally, I hope that you will adopt them.

Senator KENNEDY. I think you have some very interesting ideas. You reminded us about the importance of the role of the junior colleges in science and science education, of the contributions that they can make. I think your suggestions are very interesting and will be very helpful to us.

Senator Schweiker.

Senator SCHWEIKER. In your statement, you cited the figures under the CAUSE program. I note the difference 28.8 percent—this is on page 6 of your testimony— 28.8 percent of the grants for 22.9 percent of the funds were made to 2-year colleges. Then you say in fiscal 1977 the set-aside was dropped, Congress directed that CAUSE emphasis should be on 2- and 4-year undergraduate institutions.

Now, since getting this testimony together, do you have any indication at all as to what is happening in that category? Is it still too early to assess whether the funding has decreased or not?

Ms. SINGLETON. I do not have any idea at all at this point in time. Those awards have not been made yet so we cannot tell how the junior colleges may fare with the current year's program awards. But as soon as that information is available, we will be happy to get it to you.

Senator SCHWEIKER. Very key point. I think you raise a good issue.

Ms. SINGLETON. Thank you.

[The prepared statement of Ms. Singleton follows:]

Testimony

for

the American Association of Community and Junior Colleges

by

Lillie King Singleton
Institute Associate
University of Alabama
Institute for Higher Education Research and Services

before the

Subcommittee on Health and Sciences

of the

Committee on Human Resources

U.S. Senate

March 3, 1977

Mr. Chairman, my name is Lillie King Singleton. Currently I serve as Institute Associate in the University of Alabama's Institute for Higher Education Research and Services while working toward my doctorate in higher education administration. I am here to present the views of the American Association of Community and Junior Colleges and its member institutions on science education in the two-year colleges.

From 1967 to 1975 I served as Chairperson of the Division of Natural Sciences and for part of that time also as Institutional Grantsperson at Lawson State Junior College in Birmingham, Alabama. Part of my work at the University involves providing services to the state's junior colleges and I hope to be of continued service to Alabama's two-year colleges when my doctoral work is completed this spring. I have also had considerable experience with NSF science education programs, including the old College Science Education Programs and summer institutes for science students and teachers. I have been a member of the National Science Teachers Association since 1958, and have held several leadership positions. In 1970-71 I served as President of the Alabama Association of Junior College Science Teachers.

The community and junior colleges and technical institutes on whose behalf I speak today are a major force in higher education today. Unfortunately, to date their role has not been adequately recognized in science education awards made by the National Science Foundation.

In his recent testimony before this Subcommittee, Science Education Division Director, Dr. Harvey Averch spoke of his Directorate's plans for fiscal 1978. These are designed "to strike a reasonable balance between our responsibility to provide the educational base for our research systems and the need to be responsive to new audiences who have broader, more generalized requirements for science education." Implied here, I believe, is a response to the concerns that AACJC has been expressing over the years. I hope my statement today can be viewed as a constructive set of suggestions to help NSF reach this goal.

I will make three major recommendations:

First, that for a period of several years, until it has time to have impact, a setaside for two-year colleges of 30% of program funds should be provided for those programs which support science education at the undergraduate level. Currently these programs include Comprehensive Assistance to Undergraduate Science Education (CAUSE), Local Course Improvement Program (LOCIP), and Instructional Scientific Equipment Program (ISEP). If program names are changed or programs are merged, as NSF currently plans, the principle would remain the same.

Second, the Science Education Development and Research Division should be given funds to undertake a needs assessment of science education in two-year colleges. This needs assessment could ultimately lead to a restructuring of NSF science education programs so that they better meet the needs of this type of institution. For example, we would hope for a reinstatement of a program supporting science and engineering technologies which would address a very important aspect of the two-year college role in science education.

Third, to correct what appears to be a general inequity in the peer review process, NSF should make sure that a majority of reviewers of proposals from two-year colleges are themselves two-year college people.

Numerical and sociological impact of two-year colleges. I earlier asserted that two-year colleges are a major force in American higher education. They currently enroll over four million students in degree programs. In percentages, this is about 33% of the total undergraduate population in the nation, and nearly 55% of entering freshmen.

Community and junior colleges and technical institutes are the point of first access to postsecondary education of many of the groups that NSF -- and Congress -- is anxious to serve and draw into scientific careers. Included here are Blacks, Mexican-Americans, American Indians, women, older students and low income persons of all types. By neglecting the needs of the two-year colleges in science education, the needs of these people are also being neglected. Two year college enrollments are 16% minority and 10% black. Of blacks enrolled in undergraduate studies, 28% attend two-year colleges.[1]

Women are attending college in dramatically increasing numbers. According to Census Bureau figures, the total undergraduate enrollment of women increased by 45% from 1970 to 1975. Much of this increase is attributed to the number of older women attending college -- the increase in attendance for women from 25 to 34 years of age increased by more than 100 per

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1. Office of Civil Rights data.

cent during these years. The two-year college is attracting an impressive share of these women. Recently published fall 1976 enrollment figures show this. From 1974 to 1976 the number of full time female students in all institutions increased by 11.3 per cent, but in two-year institutions the increase was 22.4 per cent. Over the same years the number of part time female students in all institutions increased by 16.8 per cent, but in two year institutions the increase was 22.5 per cent.[1]

A number of two-year colleges enroll sufficient numbers of minority students (over 50%) to qualify and participate in the MISIP (Minority Institution Science Improvement Program) program. However, most minority students must be reached through other institutions, and science education support to two-year colleges is an important means of assisting these students.

56% of first and second year undergraduate students with family incomes under $10,000 attend two-year colleges, while 46% of such students from families in the $10,000-14,999 do so.[2]

<u>What is the two-year college role in science education</u>? Actually we can point to three roles.

1) Two-year college students in baccalaureate degree programs. Many students who will get B.S. or B.A. degrees begin their work at a two-year college. About 41% of our current students are in transfer

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1. See <u>Chronicle of Higher Education</u>, February 7, 1977, February 22, 1977

2. Bureau of the Census Data: School Enrollment. Current Population Reports: October 1975.

programs. A study of the two-year college freshmen class of 1968 revealed that 52% had transferred by 1972. Considering the numbers involved, this is a lot of students. Currently about 1,600,000 students are enrolled in transfer programs, many in the scientific disciplines.

2) Two-year college engineering technology occupational programs. These science programs train students to work with scientists and engineers and in technological occupations that require scientific competencies. About 38% of the two-year college students are enrolled in occupational programs and of these, half are in science and engineering related programs -- at least 750,000 students.

3) Two-year college contribution to science literacy. This comes about in many ways: courses taken by students in non-scientific curricula as well as the colleges' active adult education and community service programs. As community based institutions they have great ability to reach out to people for courses and public programs on science-related subjects.

The support which two-year colleges receive from NSF is nowhere near a level appropriate to their impact on the education of students in sciences.

Consider the total NSF budget for a moment. The program level (appropriated funds plus deferrals and carryovers) for fiscal 1977 is $797.9 million. As we know, much of this budget funds research, most of which is carried on in universities and four-year colleges, and while not for education as such it provides research experience for faculty and students and general strength to these institutions. The 1977 budget for science education is $74.3 million -- less than 10% of the total NSF budget.

I wish I could tell you exactly the portion of this 10% which goes to two-year colleges. Even of those programs which are directed toward undergraduate education the portion is small. The National Council for Resource Development, an adjunct council of AACJC, has analyzed some of NSF's awards in the science education resources improvement and manpower programs for fiscal 1976. (See the next page).

Thus, RULE (now LOCIP), designed to give teaching faculties the chance to do innovative work in their courses, gave 6% of its grants (4% of funds) to two-year colleges in fiscal 1976.

In ISEP, for equipment for undergraduate science courses, 5.2% of the grants (3.4% of funds) were made to two-year colleges.

CAUSE, comprehensive undergraduate program assistance, had a setaside for two-year colleges in fiscal 1976. And note the difference -- 28.8% of the grants for 22.9% of the funds, were made to two-year colleges! In fiscal 1977 the setaside was dropped, though Congress directed that the CAUSE emphasis should be on two-year and four-year undergraduate institutions. We do not yet know what the story will be for CAUSE awards this year. However, if the portion awarded to two-year colleges is down significantly we will feel that an injustice has been done to our colleges and to their students.

In pointing to these problems I do not wish to point an accusing finger at the NSF staff. Indeed, many have been exceedingly cooperative, have willingly appeared at meetings and provided information about NSF programs. We very much appreciate the cooperation of Dr. Harvey Averch and his staff.

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NATIONAL COUNCIL FOR RESOURCE DEVELOPMENT

Categorical Funding Task Force

FY 1976 Information

AGENCY

National Science Foundation

Program Name	Dollars Expended	Dollars obtained by Community Colleges	Total Number of Comm. College Rec. Awards	Total Number of Awards
1. Comprehensive Assistance to Undergraduate Education (CAUSE)	10,000,000	2,290,000	17	59
2. Undergraduate Instructional Scientific Equipment	2,900,000	101,100	*17	327
**3. Restructuring Undergraduate Learning Environment Program (RULE)	1,000,000	37,000	** 4	72
4. Student Originated Studies	972,000	-0-	-0-	69
5. Secondary School Student Science Training	1,900,000	-0-	-0-	***125
6. Women in Science	946,000	5,465	**** 1	33

*122 Proposals submitted - a 30% decline from 1975.
**RULE Program has changed to Local Course Improvement - 11 proposals submitted.
***Community Colleges not eligible in 1975; however, they will be eligible in 1976.
****Cabrillo College, California.

However, it would appear that there are certain "systemic" problems which need to be corrected. I will note some of them here:

1. Lack of understanding of the unique function, programs and teaching methodology at the two-year college. Until this year no staff members at NSF have had experience at these colleges. As a result, programs and guidelines have been developed which may effectively meet the needs of science programs at other types of institutions but do not necessarily mesh with two-year college needs.

We recommend that Congress provide funds and require NSF to undertake a thorough needs analysis of science education programs at community and junior colleges. Following this, programs can be developed or revised which are better suited to two-year college needs. This should attract more an better proposals since the potential for success and real benefit to the two-year college science teaching function would be greater.

Secondly, we recommend that NSF establish a program similar to the now-discarded science and engineering technology program -- a program which will recognize the unique role of the two-year college in the production of technological personnel who work with scientists and engineers or in occupations requiring a base of scientific competence. This type of program, developed in consultation with two-year college people involved in this type of education, would serve important needs while making a substantial contribution to our technological economy.

2. Peer Review. NSF should take extreme care to assure that a majority of the reviewers of two-year college proposals for ALL programs be two-year college people. Only these readers will have an adequate understanding of the function and context of the two-year college. Thus the proposals would

be judged by people who truly are "peers" of the applicants.

Two-year colleges may suffer in the reviewing process from an elitist attitude toward their faculty and their programs. For example, it is true that fewer two-year college faculty hold the Ph.D. than do faculty at four year colleges and universities (although many hold degrees in science teaching). Since their function is teaching freshmen and sophomore courses, and not research, it can be argued that their ability to teach is what should count. Faculty from elite universities may not share this value and in effect may be biased against two-year colleges. Again, we have noted that about half of two-year college students are in occupational programs of which about half are engineering and science-related. Although many of these program credits are ultimately transferrable toward a baccalaureate degree, university-based reviewers may erroneously view them as not "scientific" and not deserving of NSF support.

Reviewers who come from two-year colleges would understand these factors and judge the proposals from the point of view of their quality. Inappropriate reveiwers lacking two-year college experience can misjudge proposals because of their lack of knowledge of the different institutional settings.

One consequence of a fairly consistent rejection pattern is that two-year colleges are discouraged from submitting NSF proposals -- after all, there has to be some chance of success before it seems worth the effort and cost. The result is that NSF receives relatively low "proposal pressure" in most programs from the two-year colleges, and ironically this situation gives a rationale for the low level of awards to two-year colleges.

Interestingly, in the CAUSE program, where NSF is required to fund two-year colleges (or was in fiscal 1976) the pattern is different. For CAUSE, 60 per cent of the reviewers of two-year college proposals are from those colleges. In 1976, 19.2% of all CAUSE reviewers were from two-year colleges. Overall in the Science Education Resources Improvement section, however, this pattern does not apply. The list of reviewers of SERI programs contains 828 names of which we were able to identify 44 of these names as being from two-year colleges -- slightly over five per cent. For 1976 proposals, 7.2% of ISEP reviewers, and 8.6% of LOCIP reveiwers, were from two-year colleges. In the Science Education Development and Research Division only 2.4% of the reviewers were from two-year colleges. None of these figures, of course, tells us how reveiwers were allocated among specific proposals, but the figures do show that the pool of two-year college reveiwers is small.

3. Program guidelines or requirements specifically or indirectly exclude two-year colleges. Some examples:

a. The fiscal 1977 guidelines for the Pre College Teacher Development in Science Program specifically exclude two-year colleges. With their expertise in teaching, it could be assumed that two-year colleges have something to offer high school teachers who grapple with the same problem. In almost no cases are community colleges a part of local school districts. They operate quite independently, yet are community based and in some communities are the only accessible institution of higher education. To exclude the two-year colleges from eligibility deprives many pre-college teachers of a convenient and local source of developing a productive relationship with college science faculty.

b. The guidelines for the Women in Science program do not exclude two-year colleges (one grant was awarded) but they ignore the important possibility of attracting women into scientific careers at or through the technological/occupational levels. For some women, and perhaps especially those from "disadvantaged" backgrounds, the interim step may be less frightening and therefore more attractive. Many then would see the possibility of taking the next step, while others would have accomplished entry into the non-traditional science-related occupations.

Recommendation: An immediate step to correct some of these problems would be to direct NSF to open its eligibility requirements whenever appropriate to allow two-year colleges to compete for NSF funds.

In closing, let me summarize the recommendations I have made during this testimony.

1. A 30% setaside is needed for two-year colleges in those programs supporting undergraduate science education. Currently these are CAUSE, LOCIP and ISEP.

2. For two-year colleges, the concept of "peer" appropriate for proposal review must begin with true peers, those involved in that educational setting. A majority of two-year college proposal reviewers should be two-year college people.

3. NSF should be provided with additional funds to undertake a needs assessment of science education at the two-year college. This will provide the factual and conceptual basis for the development of NSF science education programs and program requirements better meeting two-year college needs.

4. Among such programs should be one which funds science and engineering technology courses in which two-year colleges are heavily involved.

5. Finally, NSF should engage in positive outreach to two-year colleges and other undergraduate institutions which provide science education to a significant porportion of American students. We recognize and appreciate the work the NSF science education staff is already doing in providing technical assistance to this clientele. One clear problem is that the staff apparently cannot afford the travel which would permit more such activity. A larger travel budget, particularly directed toward informing and encouraging broader participation in NSF programs, would help.

An approach which might be helpful is that adopted by the National Endowment for the Humanities. This is the "consultant grant," low cost and available to a high percentage of applicants. The grant pays for the services of a consultant who is an expert in the field who will help the applicant analyze and improve the course under consideration.

My thanks to the Chairman and members of the Subcommittee for their attention to these recommendations. Naturally, I hope they will be adopted.

Senator KENNEDY. Dr. Jackson.

Dr. JACKSON. Thank you, Mr. Chairman, and thank you, Senator Schweiker.

I have prepared testimony that I would like entered into the record.

Senator KENNEDY. We will make all the prepared testimony part of the record at the conclusion of your testimony.

Dr. JACKSON. I will not read from my prepared testimony. I will only make a few short comments, and then be prepared to answer any questions you might have about my testimony or about my comments.

I first want to address the problem of minorities in science, but this will not be the only thing I will address today.

I am concerned that NSF does not understand the urgency of this particular problem. It has been a little bit disheartening to me that NSF has not been able to pursue with vigorousness and imagination a program that was set up to address a large number of the problems of minority education.

We have heard today from junior college people. When we prepared our testimony last year, we were well aware of the fact that a large number of minority students are going to school in junior colleges. We would have hoped that the National Science Foundation would have coupled the minority centers programs with some of the efforts of the junior colleges to try to improve the science education of those schools.

At this time I would also like to take the opportunity to suggest that the name of the minority graduate centers be changed to something that would be more appropriate to its overall purpose, such as resources centers for science and engineering. The reason for doing that is that even though we put in a substantial component of graduate research, we also put in substantial components of undergraduate education, elementary and secondary education and community education.

What we get as a response from the National Science Foundation is not an enthusiastic acceptance but a go-slow approach. In fact the National Science Foundation's Assistant Director for Science Education in his testimony before the House suggested that in his fiscal year 1979 testimony before that body he will have a cost-benefit analysis of all the various programs. This is very strange to me when he has no program to do a cost-benefit analysis of.

He is using economic jargon and a pseudoscientific approach to address the question of minority participation in science or engineering. I suggest that if he really wants to understand some of the problems of minorities, he should pick up and read a copy of the National Board of Graduate Education's report, that came out in June of 1976, on minority group participation in graduate education or the Sloan report that came out in 1974 on minorities in engineering.

It is clear when resource centers for science and engineering were first proposed, it was a three-pronged approach to the problems of minorities in science and engineering. It was to attack the problem at the graduate level, at the undergraduate level, and at the elementary and secondary level.

It was not a single-pronged approach. The effort was to try to increase over the long term the whole base of minorities going into science. I think you have heard a lot of this before, so I will not continue in this view.

As recommendations, we do not think the resource centers for science and engineering should be funded at the expense of the other minority programs in the science educational directory. We do think that the centers program needs to be increased for fiscal year 1978 from $1 million which is in the authorization request of the House to a total of $7 million.

The reason is, that this would allow two centers to be funded in fiscal year 1978 on a startup program at $3 million each, and it would leave the Foundation with $1 million to continue their studies.

Now, if no moneys are available for the startup of two centers in fiscal year 1978, it means that you will be to the fiscal year 1979 before any centers may be started. By that time the whole impetus that this program could have had in the minority community will be lost.

We think the graduate traineeship programs should be increased from $1 to $2 million. We believe that high school programs should be increased, because it is clear that the minority centers cannot impact every high school in this country, and there should be money available for particular high schools.

We also feel that the MISIP program which has been a valuable program for 4-year schools with large numbers of minorities in them, should be increased to $6 million instead of being cut by $70,000 as requested by the previous administration.

Now it would be foolish of me, extremely foolish of me, to sit up here before you or before anybody really and talk about increasing number of minorities in science and engineering if we are going to cut back the opportunities for science and engineering across the country. A very pragmatic point of view, and pragmatic in the sense that the health of the science and engineering communities depends to a large extent on the $700-and-some million that National Science Foundation expends in universities, and it would be very foolish of me to say, increase the number of minorities in science and engineering if we do not have a viable scientific and research establishment. It is further unpatriotic of me to talk about decreasing the National Science Foundation's overall budget when I know that some of the major problems in this country are technological problems that will need technological solutions.

This brings up a point that the National Science Foundation's education directorate and some of the scientists in the community as a whole have missed about the importance of educating the community to the problems of science and how technology can impact their lives, and how a rational approach to some of these problems is good for them.

Until the community as a whole understands this, we will always have difficulty in trying to get substantial funding for scientific research that some people feel is just the frivolous waste by some academicians on some particular campus doing things that are not very important.

In fact, I remember when I was a graduate student in 1961, that there was a Professor Rowland who was chairman of the department of chemistry at the University of California at Irvine. He was studying fluorocarbons. At that time nobody knew that fluorocarbons might be a particular problem. It just happened to be an interesting chemical system that you could study. It now turns out that it may be one of our major pollution problems.

From those studies started some 20 years ago, we began to understand what the impact of putting in a supposedly safe chemical like a fluorocarbon into the atmosphere might do to the overall atmosphere. Whatever the outcome of that particular question, the whole point about scientific research, it gives useful data that has many possible applications.

To give a further example, I was at Bell Labs yesterday, and they have a computer simulation program to model the atmospheric interactions in New Jersey and New York. It takes 125 coupled differential equations to parameterize this particular problem. In those differential equations, you have a lot of parameters that have to be individually measured in the laboratory.

So the problems of our society are complex and they will not be solved by taking childish approaches to these problems. It is imperative that the scientific research establishment that has been allowed to decay over the last 8 years be funded at a level that will allow a modest growth if we are going to have the talent and skill to solve our problems.

Thank you, Mr. Chairman.

Senator KENNEDY. Let me ask about these resource centers. As you quite properly pointed out, there should not be an expansion of the resource centers at the expense of other efforts at NSF for minorities. I think that the resource centers obviously would be an outreach program in terms of minorities and others than might not be exposed to science and a career in science.

I think there are many groups in our society that have not really been sensitized and made aware of—these opportunities may very well have some very substantial qualities to contribute in the whole area of science and research. What we are really talking about here, at least as far as I'm concerned, is that there may be poor whites down in Appalachia, for example, that have very little understanding of the opportunities in science and science education. They have abilities and interests and should be exposed to the prospects in science and education. I understand from what you are suggesting here that you see these resource centers as a way to reach out into the community, to expose the possibilities for careers in science, to individuals who for one reason or another, whether they are poor whites or blacks or for whatever kind of reason, have not had the opportunity to be exposed to it.

From these centers we can awaken some opportunities for careers in science that otherwise might be denied.

Dr. JACKSON. That is correct. The point is that when we were looking at this problem last year, we looked at what had happened over the past, say, 5 or 6 years. Everybody knew that there had been a problem in underrepresentation of minorities in science and engineering. What we need to do is increase the base and flow into established institutions. It would be a way of reaching out into the community and identifying and working with people in the community to get more participation in science.

[The prepared statement of Dr. Jackson follows:]

March 3, 1977

Prepared Statement

of

Dr. William M. Jackson

before the

Senate Subcommittee on Health

and

Scientific Research

Hearings

on

The FY-78 Authorization Legislation of the

National Science Foundation

Mr. Chairman and members of the committee, my name is William M. Jackson and I am a member of the Board of Directors of the National Organization of Black Chemist and Chemical Engineers. On behalf of all of our members I would like to thank you for the opportunity to testify before you today on the FY-78 Authorization Bill of the National Science Foundation.

We support the proposed budget of the National Science Foundation but feel that additional funds should be supplied for the minority programs at the Foundation. I would like to spend part of the rest of my time discussing some of these programs and then finish my testimony by discussing our organizations support for the FY-78 budgetary emphasis of the Foundation.

The National Science Foundation has requested $8,000,000 for FY-78 for all of the minority programs located in the Science Education Directorate. This represents a 3% increase over the FY-78 budgetary request and is graphic evidence that the Foundation has not sensed the urgency of the underrepresentation of minorites in the scientific and engineering fields in this country. The proposed increase does not take care of the rate of inflation over the past year, let along provide money for a significant expansion of the Foundation's effort in this field. The foundation persist in it's slow and cautious approach to this problem. In fact the Assistant Director[1] has called for another "Full-Scale Analysis of the various

Belief and Value Systems concerning Minority Science Education". The purpose of this analysis is to develop "systematic evidence for the Benefits and Cost of alternatives programs". In the last three years two full scale reports totaling 500 pages have appeared that deal with the problem of Minority Participation in Science and Engineering. One is the Sloan Report on "Minorities in Engineering" and the other is the National Board of Graduate Education's report on "Minority Group Participation in Graduate Education". Both of these reports deal with "Belief's and Values" but both reports go further than this and make specific recommendation. I would suggest that the Assistant Director can dispense with his analysis and read these reports. Furthermore, it is difficulty to see how he is going to do a "Cost-Benefit Analysis" when none of the program have really been funded at any appreciable level.

The FY-78 budget ask for a $200,000 increase in the Minority Centers for Graduate Education which is clearly inadequate for the anticipated program. I would like to take this opportunity to change the name of the program to "RESOURCE CENTERS FOR SCIENCE AND ENGINEERING". This will remove the stigma that has been attached to the Minority and will emphasize that the program is <u>not</u> designed to set up isolated enclaves of minority students at majority or minority schools.

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1. February 23, 1977 Statement of Dr. Harvey Averich before the Subcommittee on Science, Research, and Technology of the House of Representatives.

The program was in fact designed to impact the problem at three different levels. It was aimed at those students with ability who have finished undergraduate institutions that are not the traditional sources of Graduate Science Students. These students would be identified and encouraged to enter the graduate school at one of the Resource Centers. At these Centers the overall graduate program would have been designed to assure that all students have the proper preparation for the rigorous graduate courses. Since each of these centers will have substantial numbers of minority students and faculty, no student would feel that he or she had been singled out in an effort to make them feel inferior. It would break down the seige mentality that small numbers of minority students often feel when there are only a few of them at an institution. The seige mentality is a human reaction of individuals in an environment where he is identifiable different. Recent studies show that white elementary and secondary students develop the same pathology that black students develop when they are in the minority in an academic institution.

Each Resource Center will have as one of it's principle goals the strengthening of the background of the science college students that are attending regional community colleges in an effort to make their transition to graduate schools smoother. This was recommendation number 10 of the Sloan Report. Each Center will set up programs that will allow students to take advance courses at the Center. They will encourage and support the college faculty in their efforts to attain advance degrees. They will participate in joint research programs and provide support for community college faculty to do summer research at the Center. In summary they will be a resource for these schools.

No program will have a long term impact on this problem unless that program tries to increase the flow of well prepared high school students to college. Each Resource Center will set up joint programs with the junior and senior high schools in the region. These programs can and should include tutorial programs, counselling programs, early age recruitment programs, etc. The program should also contain a community education program that will educate parents and teachers to the opportunities that are available to scientist and engineers.

The Resource Science and Engineering Centers is a comprehensive approach to the problem of minority participation in science and engineering. We would like to recommend that it be funded at a level of $7,000,000 in FY-78. This would permit the Foundation to support two Centers at an initial funding of $3,000,000 per year. It would also allow the Foundation to continue it's planned activities in this area.

It is clear that the Resource Centers for Science and Engineering can not attack all of the problems around the country. We would recommend that the high school and College Student program be expanded to $2,000,000. We further feel that this program should make an aggressive effort to identify the various programs around the country that are successful and model their program after these programs.

The Minority Instiution Graduate Traineeship Program should be expanded to $2,000,000. In addition to supplying funds for minority students at predominately minority Institutions the guidelines should be flexible enough to see that deserving students are not lost in their last two years of graduate studies for financial reason. I must inject caution here though since we feel that no school should be allowed to use these traineeships as an alternative method of funding minority students.

In the FY-78 budget the MISIP Program was actually cut $70,000. We feel that this program should be expanded to $6,000,000. This allows for a modest growth that will account for the rate of inflation over the past three years.

Our recommendation is that the total minority program in the Education Directorate be increased by $9,000,000 to $17,000,000. This is a modest total compared to the total budgetary request. It would mean that the total Education Directorate budget would have risen by 12%, which is about the increase accorded the rest of the Foundation.

Mr. Chairman as a practicing scientist and a representative of a scientific organization I am also obliged to support the rest of the National Science Foundation Budget request. It would do no good to increase the numbers of minorities that became scientist and engineers if these fields become stagnant and decay. But this is not the only reason I support the modest increase that is in the proposed FY-78 budget. It is clear that over the past eight years the research plants at a substantial number of institutions has been allowed to decay. This is an intolerable situation when some of the major questions facing our society require technical solutions. The fields of energy, environment, health care, etc. all will require new technical solutions if our way of life is to survive these solutions will come from our educational institution through the ingenious application of the available techniques and knowledge. As the question become more difficult, the approach generally becomes more sophisticated requiring new equipment. I know in my own field the finest experiment require the use of lasers as detectors that permits us to probe the quantum states of molecules. As one of the pioneers of the technique it is impossible to get good results without good equipment.

In closing we support a $9,000,000 dollar increase in the science education budget but hope that this will not be at the expense of the rest of the Foundation.

Senator KENNEDY. Let me ask the panel—and we have to move along here—but I am interested in this and I would like to hear from each of you: Why do you think that there has not been a stronger sense with Congress or the American people generally about the importance of science education and the need for increased support? Why is that? It seems to me to be such a basic and fundamental issue, and so obvious in terms of importance to our society. I am wondering why there is not a broader base of support, why people are not pounding our doors down on it. I would be interested in what you might be able to tell us.

We have four distinguished professionals here who feel very deeply about it. I would like to know how we can get a greater sense of public support.

Dr. POSVAR. I think, first of all, it is an extremely complex subject. I think the basic argument in terms of technological progress has not been sold to the American public. I think in part there is antagonism built in in our society toward the idea of corporate activity, including that which is related to research. But I think some of the fault lies with higher education and investigators themselves.

There has been a tendency among the public and the Congress and legislators in Pennsylvania and elsewhere, to perceive educators as persons who want public funding and who also want independence and autonomy and who do not want to answer difficult questions about priorities and who have been unwilling or unable to explain the complexities of their activities to the public and sell them to the public.

I think that we have a strong duty in higher education to tell our story in terms of the national interest which we think is our common interest.

Dr. WILLIAMS. I think there are a lot of people who at an early age view science as being hard.

We used to say at our small college we have to get out in the streets and talk to the people about science. If we get out and get involved and work with science education at a variety of different levels, I think we can get a greater public awareness.

The other day I went to a second grade class and talked to a group of second graders about environmental problems. It was an exciting thing, and I was worn out because they asked so many questions. If we in the sciences, can continue to go out and get involved, I think we can build a group of people who are really imbued with the understanding of science at its deepest roots.

Senator KENNEDY. Ms. Singleton.

Ms. SINGLETON. I would like to read briefly, in answer to your question, from a statement of Dr. Averch in his presentation before the subcommittee.

It says: "I believe that the NSF, OMB and the Congress are approaching agreement on the value of issues, although debate certainly will continue about appropriate levels of resources. In fiscal year 1978 it would be fair to say that our mission is two-fold: To improve the science education system through support to institutions and individuals," yes, but here is the catch: "To foster science literacy."

I think the answer to your question probably lies more in our giving additional attention to making the general citizenry aware of the impact of science and the interrelations of science to daily life that they probably do not see very easily nor vary readily. Science and technology seem to have gone too far over the heads of the masses of the people. The people must know what is going on! Here, I think the junior colleges are in a position to be of tremendous help to the country. Because they are community based institutions, the junior colleges can reach out and touch the people at the grass roots level. It is to this kind of concern—the implications of science and technology to daily living and decisionmaking—that we need to give much additional attention. I think Dr. Averch, OMB, and the Congress would agree with me in this assessment.

Senator KENNEDY. Dr. Jackson.

Dr. JACKSON. I think to a large extent, as a scientist, I'm going to say to a large extent, it is a problem of scientists in general. Scientists love to do research. They get involved in their own little bailiwicks, and they do not want to talk to other people. If they stay in the lab and work 80 hours a week and publish 8 or 10 papers a year, their colleagues will like them and say they are great scientists.

You can say all you want, but unless the scientists can communicate to the people the enthusiasm that they feel about doing science and why it is important, then I do not think that you can ever really have a firm base in education to evaluate the public. Because, really, one of the most intellectually stimulating periods in the history of mankind occurred between 1900 and 1930 in the revolution of physics. It was a period of time when scientists were uncovering new facts with no theories to understand them. They literally pulled themselves—people say how tough science is, but what really happened was, that all of the complicated mathematics of quantum mechanics was developed by people who did not know anything about mathematics but had to go find out to explain their data.

I do not think this has even been communicated to people of what it is all about. Scientists are really out there trying to understand nature at all levels, complicated interactions that occurs when a car exhaust fumes go into the air. Molecules absorb light, you have dust particles, that molecules react on forming new and sometimes dangerous compounds. Basically all those molecules are running around out there hitting each other and reacting and forming things that may or may not be desirable.

There are any number of ways to communicate to people if you take the time and try to do it.

Senator KENNEDY. I want to thank you all very much for your presence here and for your testimony. This information will be very valuable and very helpful to us.

Dr. JACKSON. Thank you.

Senator KENNEDY. Our next panel will discuss the National Science Foundation and the Industrial Community.

James E. Barger, chief scientists, Bolt, Beranek & Newman, Inc., Cambridge, Mass.; E. J. Johnson, G.T.E. Laboratories, Inc., Waltham, Mass.; and Arthur S. Iberall, president, General Technical Services, Inc., Upper Darby, Pa.

I welcome my friends from Massachusetts.

We will include all of the statements in the record. I do not know if you have had a chance to review the testimony of Tuesday's hearings. I do not know whether I can remember it exactly—there are members of the National Science Foundation here so they can help me on it—but basically the NSF testified that there was not really much interest in basic research in the industrial community.

STATEMENT OF JAMES E. BARGER, CHIEF SCIENTIST, BOLT, BERNANEK & NEWMAN, INC., CAMBRIDGE, MASS.; ACCOMPANIED BY E. J. JOHNSON, G.T.E. LABORATORIES, INC., WALTHAM, MASS.; AND ARTHUR S. IBERALL, PRESIDENT, GENERAL TECHNICAL SERVICES, INC., UPPER DARBY, PA., A PANEL

Mr. Iberall. For the record, notice that there were three laughs when you sad that, Mr. Chairman.

Senator Kennedy. I think that is a fair reaction to what was said. Let us have your testimony, and I will come back to it.

Mr. Barger. Let me first summarize what I'm going to say in a few words.

NSF is about the only Government agency now responsible for fostering basic science, now that DOD has become mission oriented. NSF, as well as all of us, are also becoming aware of the problem that we call technology transfer.

My point is going to be that industry, in particular, a segment of industry that I will emphasize, has a very good record at this, and I'm going to give a few firsthand examples.

My basic recommendation is simply that NSF be required to allow industry to compete with all other institutions on an absolutely equal basis, scientific merit being the criteria.

If I can expand just briefly on these points. First, this special branch of industry that I am describing—it does not have a trade association, it does not even have a name—was given special attention in the recent NSF report "Roles of NSF with Industry," that was issued in December by NSF. In that report this group that I am going to speak of was called the Route 128 Palo Alto Enterprises.

I find this alliteration useful because I am on Route 128.

I would like to coin a different phrase and call this the "research and development services industry."

Senator Kennedy. I like that better too. Everybody shouldn't think it was just something for Route 128 and Palo Alto.

Mr. Barger. There is a good deal in between, I am quite certain.

Now, the distinguishing characteristic of these research and development services industries is that they were founded and they are staffed today by basic-research trained scientists. The main thing they are seeking is to get away from the basic research orientation exclusively, and to add to this a mix of mission-oriented or problem-oriented research. They are also characterized by the desire to see a public demonstration of the ideas that stem from their basic research.

I would like to give three first hand examples of this public demonstration of the fruits of basic research, which have contributed to the founding of three industries, now major ones, in this country.

I am not suggesting that this organization. Bolt, Beranek & Newman, Inc., founded these industries all by itself. But it played a role by demonstrating the features of these new industries as they now exist, more are emerging.

The first example has to do with noise control. This is environmentally, socially, and economically an important industry now. In about 1948, the Department of Defense reduced funding of the acoustics laboratory at MIT, and those people, seeking basic research support, formed a little company and solicited research support from that base.

I will not talk about the details of the intervening 25 years, but these people have now more Fellows of the Acoustical Society of America than any other institution. They have written more books on acoustics than any other. They have done more basic and applied research on noise control than has been done at any other single institution that I can think of.

This was the first company that in fact offered as a product, and I use that word advisedly here, research in acoustics.

Now the second new industry that I want to describe is time sharing computers. The company received a basic research contract back in 1957 to study how computers can be used by many people at once. In 1962 these same scientists gave the first public demonstration of a time-sharing computer network.

Senator KENNEDY. Of what?

Mr. BARGER. Of a time-sharing computer network. Time sharing is the sort of business where a company owns a large computer, or a university has a large computer centrally located, and there are teletype units or other terminals spread all over, potentially, the world. Different people use the device, the computer, simultaneously.

This is a large service industry now.

The first public demonstration of this was in 1962.

The third example is the network digital communications business. The DOD was looking for a way to interact and share the use of the larger computers at the various important DOD-funded research institutions scattered all over the country. They funded a basic research project at BBN. This research resulted, in about 1972, in the establishment of what is known as the ARPA network. This is a network of computers that is operating—in fact BBN still operates the control center for the ARPA network. It connects also to computers overseas by satellite links, and throughout the country.

Three years ago, BBN obtained from the FCC a common carrier license to use the national telephone network to provide for commercial packet-switched communications. This is a way of making much more efficient use of the lines than is current practice.

At the present time the FCC has granted two other companies similar licenses, and there is every reason to believe at this time that the digital communication network, using this technology, is going to become a multimillion-dollar industry.

Now my recommendations, based on my view of the role of industry and NSF, are five.

First, remove the special criteria that are presently placed on unsolicited proposals for basic research from industry. In fact, the NSF-industry task force, made up of 13 senior NSF staff members, made exactly the same recommendation, but it was reversed by the National Science Board.

The final report on NSF-industry relations said there was some disagreement on this issue. I recommend that you help resolve this disagreement.

My second recommendation is to allow a fee on contracts for basic research. I have firsthand knowledge of a contract negotiation in which NSF is seeking to obtain basic research, but at the same time are seeking to avoid paying a fee. Fee for an R. & D. services company includes the cost of capital. If that is not recovered, as we do in the fee, then we cannot provide for the cost of payment of salaries before payment by the client.

Senator KENNEDY. Does it include overhead too?

Mr. BARGER. Overhead is included in the allowable cost, but the cost of capital is not an allowable overhead item. I would recommend it be allowed.

Also, I recommend that the NSF seek to have more industrial members review research proposals. At the present time, according to NSF figures, only about 3 to 5 percent of the reviewers are from industrial organizations.

I believe that constitutes a bias which I would like to see reversed.

The next recommendation deals with cost sharing. This is a concept in Government procurement practice which is often engaged in by NSF. This concept is not appropriate for the R. & D. services industry.

Our only source of income is the cost and fees for doing research. We do not have anybody else's money to share with the cost of our research.

The last recommendation has to do with manufacturing industries as well as the research and development services industry. I will not belabor this. It is described in the NSF-industry relations report, and it is for NSF to take a lead in reducing some, or removing some disincentives for basic research that is funded by manufacturing industries with their own money.

They have the money, but there are disincentives for them to use it for basic research.

I concur in that recommendation made in the NSF-industry relations report.

Thank you.

[The prepared statement of Dr. Barger follows:]

TESTIMONY ON NSF-INDUSTRY RELATIONS

Presented before the Senate Subcommittee on
Health and Scientific Research

Thursday, March 3, 1977

Dr. James E. Barger
Chief Scientist
Bolt Beranek and Newman Inc.
50 Moulton Street
Cambridge, Massachusetts 02138

Testimony on NSF-Industry Relations

Section		page
I.	SUMMARY	1
	A. Background	1
	B. Recommendations for Subcommittee Consideration	3
II.	NSF AND THE NATIONAL STRATEGY FOR NEEDED SCIENTIFIC AND TECHNOLOGICAL ADVANCES	4
III.	CURRENT NSF POLICY IS BIASED AGAINST INDUSTRY PARTICIPATION IN BASIC RESEARCH	7
IV.	R&D SERVICES INDUSTRY: A PROVEN GROUP OF EFFECTIVE RESEARCH INNOVATORS	8
V.	CONCLUSIONS	11
VI.	BIOGRAPHY	12

I. SUMMARY

A. Background

Fundamental scientific research is too often divided into two separate activities - basic research and problem-oriented basic research. This view is reflected in the policy of the National Science Foundation and by the principal findings of an NSF report on research in industry [1]. This report elaborates on the dichotomy by stating that NSF will fund "basic research, which is carried out largely in academic settings." Problem-oriented (or mission-oriented) basic research, according to the report, is to be funded by industry and by mission-oriented agencies — not by NSF. The report reaffirms the present policy of NSF toward funding research in industry. In other words, the current NSF bias against support of basic research in industry will continue.

I believe that this NSF policy of severely restricting funds for basic research in industry is harmful. It hurts our scientific community and that community's ability to support the strong economic and political position of the United States. Cost-effective scientific innovation needs the features of both university and industrial laboratory environments. I will cite, later in my testimony, firsthand experiences of my own company — Bolt Beranek and Newman Inc. — as examples of industry's ability to achieve the goals NSF is directed to encourage for the entire scientific community.

It is important for you to understand that there are scientists, more than a dozen of them intimately involved in the operations of NSF, who share my opposition to the NSF bias.

[ ] "A Report on Research in Industry: Roles of the Government and the National Science Foundation", National Science Foundation, December 1976, pg. 2.

 Hold all

The Preliminary Report of the NSF-Industry Task Force recommended that NSF "... Allow researchers in industry to compete on an equal basis with other researchers for basic research funds" [2]. This Task Force was composed of 13 senior staff members of NSF.

Who are these "researchers in industry"? The organizations that comprise "industry" are very diverse. There is one class of industry, however, that I shall emphasize in my testimony — the research and development services industry, of which my Company is a part. This class of industry is given special attention in the 1972 Report of the NSF-Industry Relations Committee, where the class is described as "Route 128 - Palo Alto endeavors" [3]. The needs and potentials of R&D services industries, on the one hand, and manufacturing industries, on the other, are very different.

Most R&D services corporations were founded and are staffed by scientists trained to perform basic research. These scientists leave their universities to establish an intellectual environment that is as conducive to effective basic research as the one they left. In addition, they seek to replace the old principal objective – to teach – with a new principal objective – to create a wide market for their research and its derivative products and services. In doing so, they achieve a mix of basic research and problem-oriented basic research. Moreover, basic research ideas conducted within the R&D services industry often are developed into applications of new scientific knowledge that are demonstrated as a new product or service. Completion of this

[2] Reference 1, Attachment A, pg. 8.
[3] Reference 1, Attachment A, Appendix 2, pg. 15.

demonstration is less certain by researchers at universities, who often are not motivated to present their results in a way in which manufacturing industries can perceive any commercial potential.

Often, the research result demonstrated by the R&D services company becomes a major component of business for large manufacturing and services corporations, which are better equipped than the innovator to establish the business. Often, too, the innovating R&D services company derives little financial gain or may even sustain loss from the demonstration. The ability of the innovating companies to sustain losses that accompany gains for other companies is characteristic of this type of industrial enterprise. Since their principal business is contract research and development services, which are engaged at a small profit, they are not deferred from basic research by other firm's successes.

B. Recommendations for Subcommittee Consideration

I recommend that the Subcommittee:

1. Require the NSF to remove the special criteria that currently must be met by unsolicited proposals for support of basic research by industry organization. The National Science Board reversed the Task Force recommendation to "Allow researchers in industry to complete on an equal basis with other researchers for basic research funds." The Task Force consisted of 13 senior NSF staff-members, and I concur with their recommendations.

2. Modify cost-sharing provisions to allow current and related sponsored research to count toward cost-sharing totals. This change will help to remove the disadvantage that R&D services industrial organizations have relative to universities, which have other income that can be used to help support a

research project. I further recommend that cost-sharing provisions be eliminated entirely in cases where the proposed idea is in an area outside any commercial interest of the proposing organization.

3. Encourage NSF to develop a program to advise other federal agencies how to provide incentives and to remove disincentives to industrial basic research and development. This recommendation is currently under consideration by NSF, and I endorse it. [4]

4. Request NSF to appoint to its advisory board and committees more members of industrial organizations, chosen for their industrial committment as well as for their scientific knowledge.

5. Request NSF to incorporate, as reviewers of technical proposals, more members of industrial organizations, who would be chosen for their scientific activities.

II. NSF AND THE NATIONAL STRATEGY FOR NEEDED SCIENTIFIC AND TECHNOLOGICAL ADVANCES

By its authorizing legislation, NSF is authorized and directed to "...initiate and support basic scientific research and programs to strengthen scientific research potential in the mathematical, physical, medical, biological, engineering, social, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) to support such scientific activities and to appraise the impact of research upon industrial development and upon the general welfare." Now that other federal agencies have been directed to fund only mission-oriented basic and applied research, NSF objectives are unique. NSF policy should, and must, reflect a sound strategy effectively to mobilize efforts of our

[4] Reference 1, pg. 7.

scientific community to solve critical societal problems, regardless of whether members of that community are universities or in industry.

Recently, William D. McElroy (past NSF Director; retiring President and Chairman, Board of Directors, American Association for the Advancement of Science; Chancellor, University of California, San Diego) commented: "We must disabuse ourselves from those historical constraints which prescribe an overly strict dichotomy between the so-called basic and applied sciences. We must learn to mobilize and manage large operations to grapple with problem-focused, rather than discipline-focused issues" [5].

The essential feature of R&D services companies is the interdisciplinary nature of their organization. Those who founded them as problem-focused organizations and who staff them today are scientists trained to do basic research. These men and women left their universities so that they could perform in a problem-focused rather than in a discipline-focused environment. In this new environment, they hope to develop the fruits of basic research to the point where economically attractive products and services can be demonstrated. They seek to bridge the gap between basic research and application to national needs — the so-called "Technology transfer." John L. Allen*, has said that the desire to increase technology transfer within the United States was one of the factors underlying the recent Department of Defense move to increase basic research funding in industry at the expense of in-house funding [6]. The previous policy to increase in-house at the expense of industry funding has proved nonbeneficial to

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* Deputy Director of Defense Research and Engineering.

[5] William D. McElroy, "Basic and Problem-Oriented Research: A New Emphasis," AAS Retiring President's Lecture, 23 Feb. 1977.

[6] "Agencies Reduce In-House R&D In Favor Of Industry," Physics Today, Sept. 1976, pg. 78.

technology transfer. "To get high technology into industry rapidly, one just about has to develop the technology there in the first place," he stated.

DOD is not the only agency that has found that industry can effectively develop high technology products from basic research results also obtained by the same company. The Goldman report on NSF-Industry Relations [7] describes the R&D services organizations in these words: "This group has been, in the past, far more than proportionately productive of innovations." The report goes on to observe that many of the reported incidents of entrepreneurship originated at universities; i.e., the first incident of basic research for these companies was often supported by NSF. I am suggesting that scientists who qualified for NSF support while at a university should not be prevented from competing for NSF support once they move to a company.

Recent employment statistics for PhD-trained scientists show that, increasingly, they are leaving universities for industrial organizations. Whether this mobility is caused by an increased desire to find a problem-oriented research environment or whether it is forced by economics is immaterial. The result is the same. More basic research-trained scientists are moving into the industrial environment, and our national strategy for scientific advancement should recognize and fund the best ideas of these men and women.

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[7] Reference 1, Attachment A, Appendix 2, pg. 15.

III. CURRENT NSF POLICY IS BIASED AGAINST INDUSTRY PARTICIPATION IN BASIC RESEARCH

The present NSF policy is to support basic research in industry directly when *special criteria* can be met. These *special criteria,* which currently must be met by unsolicited proposals for support of basic research by industrial organizations, follow:

(1) The project must be of special concern from a national point of view and show promise of solving an important scientific problem;

(2) Unique resources must be available in industry for the work, or

(3) The proposed project must be outstandingly meritorious.

I have asked several NSF staff members what this means. One replied that industry proposals must be 10 times better than competing university proposals. Another said, "Just forget it; it's almost impossible to meet the special criteria."

My Company's experience substantiates these replies. Over the past 10 years, we have been encouraged by NSF staff members to prepare seven different unsolicited research proposals. One such proposal and two renewals of it have passed the special criteria, but none of the other six resulted in support. We never received an explanation for the unfavorable decisions.

It is clear that *special criteria* have resulted in negligible support by NSF for industry. The NSF funding obligations to industrial organizations during the last few years have been about \$4 million per year for basic research and about \$18 million per year for applied research. These obligations represent only about 0.5% and 2.3%, respectively, of the total NSF obligations.

An examination of the reviewers selected to review research proposals shows that only about 2.5% of reviewers are from industrial organizations. In 1975, the seven discipline advisory panels in 1975 included only 5 industrial representatives out of a total of 84, or about 6%. Moreover, NSF figures show that only 15% of the formal NSF Advisors are affiliated with industrial organizations.

NSF decisions to fund research programs are significantly based on proposed cost-sharing. This policy discriminates severely against R&D services companies, because these companies have no sources of income other than funding for R&D services. Since R&D services are the *raison d'être* for R&D services companies, there are no large profits from products that can be used as sources of cost-sharing funds.

IV. R&D SERVICES INDUSTRY: A PROVEN GROUP OF EFFECTIVE RESEARCH INNOVATORS

There is great diversity among industrial organizations. The R&D services industry is a group of organizations that are recognized to be unusually innovative. My company, Bolt Beranek and Newman Inc. (BBN),is one example of the R&D services industry. In this section, I shall give three examples of how BBN obtained support for basic research ideas and, subsequently, made the first public demonstration of the essential features of what became three different world-wide industries. These examples serve to describe the features of the R&D services organization that I believe must be sought by NSF.

You will see that the three new businesses to which BBN contributed so much are quite diverse. This testifies to our abilities to develop new ideas from basic reasearch and to bring them to commercial fruition. And, by doing so, we have helped to create new industries which lead to new jobs and national growth. Companies like ours are flexible and adaptable, moving with speed and skill into areas of technology because of our concentration of scientists with diverse disciplinary backgrounds, working in a problem-oriented environment.

My first example is the role BBN played to help [redacted] establish[redacted] the socially and economically important environmental noise control industry. The company started research in noise control in 1949, at a time when only three universities had identifiable training programs in sound and vibration control. There was no national program in noise control. We performed the earliest research on community and individual response to noise, developing the measure of noisiness still used internationally. ~~We~~ demonstrated to the country that aircraft noise can be mitigated. [redacted] by developing a series of aircraft noise-reduction techniques for early commercial jet airliners.

BBN has expanded continually on these early noise reduction demonstrations. Our employees wrote the original textbooks describing the science and technology of noise control. Hundreds of research papers have been written and incorporated into textbooks by other BBN authors. We have written noise control ordinances and regulations and developed noise control technology for almost every industry. The fundamental physics of noise generation and transmission is an on-going study at BBN. Ex-BBN employees teach noise control in universities, hold important governmental positions in noise regulation and research, and work for industries that manufacture noise control materials. The national professional society for noise control engineers was founded jointly by our employees and people from a few other companies. Today, there is a noise control industry, and to serve it, there are now over 35 universities with identifiable training programs in sound and vibration control.

87-769 O - 77 - 15

My second example is the role BBN played in the development of the time-share computer industry. BBN scientists submitted an unsolicited proposal and received support for basic research in the development of a technique for time-sharing a computer that could be used by several people simultaneously. BBN developed the idea so rapidly that in 1962, we presented the first public demonstration of the time-sharing principle. Numerous computer companies, spurred by this development, soon developed their own commercial versions of time-shared computer service. Time-sharing computer services are now a major international industry.

My third example is BBN's role in the development of the emerging computer network communications industry. In 1968, DARPA* was seeking an organization to develop a network out of the assemblage of computers that were being operated by the major DOD-supported research institutions (mostly universities). DARPA sought economies of computer resources and increased communication between the different institutions. BBN won the competition for research funds with the "packet-switching" concept.

The ARPA network was first demonstrated in 1969. Now, in 1977, it consists of over 100 computers and several communication satellite connections to ships at sea and to other continents. BBN still operates the network control center, and provides many of the system development services.

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* Defense Advanced Research Projects Agency.

In 1973, BBN founded TELENET Communications Corpoation, a commercial version of the ARPA network. It was necessary first to obtain from the FCC a common carrier license to lease telephone lines for the purpose of packet-switched message traffic. BBN's lead is being followed; recently, FCC has licensed two other firms to engage in a similar communications service. Meanwhile, TELENET has been licensed to engage in business in England. BBN will have played a dominant role in the expanding digital data communications industry.

V. CONCLUSIONS

There is a special type of industry; I have called it the R&D services industry. The corporations that form this industry have demonstrated that they play an important role in the scientific community of the United States. The special ability of these corporations is to demonstrate new technical products and services, which spring from the services industry's own basic research. Yet the R&D services industry is not permitted to compete on an equal basis with universities for Federal basic research funds.

To insure the growth and continued production of this vital American industry, the National Science Foundation must end its bias against funding basic research in industry and allow equal competition with universities — now.

VI. BIOGRAPHY

James E. Barger

James Barger was born in 1934 in Manhattan, Kansas. He was married in 1957 in Toledo, Ohio to Mary Rupp. He lives in Winchester, Mass. with his wife and four children.

Dr. Barger's degrees include a B.S. in mechanical engineering, The University of Michigan, 1957; an M.S. in mechanical engineering, the University of Connecticut, 1960; an M.A. in applied physics, Harvard University, 1962; a Ph.D. in applied physics, Harvard University, 1964.

On active duty in the U.S. Navy from 1957 until 1960, he served as a program officer at the U.S. Navy Underwater Sound Laboratory in New London, Connecticut. His research work at BBN has included underwater acoustics, biomedical ultrasonics, and hydrodynamics. In addition to research work, Dr. Barger has served as Division Director for the Physical Sciences Division and as Corporate Vice President. He is currently Chief Scientist for Physical Sciences.

Dr. Barger is a fellow of the Acoustical Society of America, a member of Institute for Noise Control Engineering, and a member of American Association for the Advancement of Science.

Senator KENNEDY. Dr. Johnson?

Dr. JOHNSON. OK. I'm sorry to see that Senator Schweiker has left the room, because I did want to make a contribution to the football controversy.

Living in New England, of course, I root for Boston College, but being a graduate of Penn State, my heart lies with the Nittany Lions. [Laughter.]

The second point I'd like to make, is that I'd like to make it clear that I appear before this subcommittee as an individual, representing myself and my colleague, Alex Lempicki. In no way do we represent G.T.E. Laboratories, the General Telephone Corp., or its management, although, of course, we are employed as scientists at the G.T.E. Laboratories. We speak only as a pair of concerned working scientists who have witnessed and have been fighting the battle against declining basic research activity in this country, and the effect on its economy.

I was very depressed to hear the comments on the cuts voted in the House, particularly having appeared before that committee. This news is devastating and I think it is shortsighted in view of the serious economic stresses that exist. NSF's role needs expanded, not contracted. It needs expanded.

All one has to do is to look at the pages of the Physical Review Letters—the principal journal of American Physics. What do you find? You find papers whose authors are Japanese, whose authors are German, and even Russian. You see the same thing in the Journal of Applied Physics. In one of our big current research fields, that of optical communication in Applied Physics, you'll find most of the authors are Japanese.

There currently exists an extensive store of scientific talent in this country that could be contributing to the scientific strength of the country in a manner consistent with the stated goals of the National Science Foundation. Yet, these people are being completely ignored in the funding policies of the Foundation. There are many well-seasoned creative scientists, who are essentially in holding patterns, and these people could be contributing to the country's economy.

Basic research is important and does benefit society. Basic research feeds innovation, innovation creates jobs to support the economy. It is mandatory that something be done about this situation.

Now, under the severe economic conditions that have existed in recent times, basic research has suffered extensively because it is long term and often it is not obvious where the impact of benefit to society will occur and even when the impact does occur, it is often very difficult to trace the origins to a single piece of research.

Where once the Defense Department and industrial corporations, extensively funded basic research, they have turned to immediate problems, as so many institutions have done, and have cut back extensively, on support for long-term basic research.

Further, the science departments in universities have stopped growing, and young scientists, for the most part, now must turn to industry for jobs.

I have detailed my arguments for an expanded role for NSF in funding basic research in industry, in my written material submitted to the committee, and in individual conversations with NSF personnel, in written comments to the preliminary NSF Task Force Committee, and in testimony before the House Subcommittee responsible for NSF.

These arguments were presented in terms of the need to fund the best basic research wherever it can be found, the need to stimulate industrial innovation, the need to maintain the viability and job creating capacity of American industry, and the need to utilize in basic research more of the young scientists who are being—are now being ignored by universities, after they graduate.

A good case for what I propose is contained in the NSF task force report. Still, NSF and, particularly, the National Science Board remains timid and reluctant to assume this new expanded role.

Mr. Doan, representing the National Science Board in House testimony, testified in essence, "Basic research in universities is in good shape"—but that isn't quite consistent with some of what we've heard from the previous panel:

> Basic research in industrial labs is in poor shape (to continue with what he said). The way to improve things is to arrange some kind of tax break for industry so that they can fund more research in universities and set up channels so that the results can be funneled back to industry.

Gentlemen, this is not the answer.

We would recommend legislation mandating the following changes in NSF policy toward industrial laboratories:

1. Earmarking some small portion of NSF budget for support of basic science in industry.
2. Removal of special qualifying criteria on proposals from industry. Within the budgetary constraints, the proposals should be in direct competition with university proposals.
3. Formulation of rules which would result in lowering cost to NSF on research in industry, such as cost-sharing.
4. Largely, to implement the first three, increased participation of industrial researchers in the peer review of proposals.

Under these recommendations, NSF should begin to fund basic research in industrial laboratories.

I'd like to add a postscript to that—actually, if NSF really wanted to fund basic research in industry, they would really have no trouble doing so under current regulations. If they are going to do it, it appears from all that has transpired in the committee hearings, they need specific directions from the committee.

I would like the opportunity, and perhaps you would prefer later, to comment on the comment that industry really is not interested. I'll postpone that if you prefer.

Senator KENNEDY. What Dr. Hackerman said on Tuesday was that industrial scientists are not terribly interested in basic research because of the long-time commitment necessary to carry out this kind of research.

Dr. JOHNSON. Substitute—well, it was your——

Senator KENNEDY. Why don't we hear from all of you and then I'll let you comment.

Dr. JOHNSON. Sure.

[The prepared statement of Dr. Johnson follows:]

TESTIMONY ON NSF – INDUSTRY RELATIONS

Presented before the Senate Subcommittee on

Health and Scientific Research

Thursday, March 3, 1977

A. Lempicki and E. J. Johnson

Testimony on NSF — Industry Relations

Section		Page
I	Recommendations	1
II	Background	3
	a. Public Funding of Research in Industry	3
	b. Benefit of Basic Research to Society	4
	c. Interaction between Universities and Industrial Laboratories	5
III	Should Status Quo be Maintained?	6
IV	Conclusions	10
V	Biographies	11

I. Recommendations

First we would like to make it clear that we appear before this subcommittee as individuals. In no way do we represent GTE Laboratories or its management although we are employed by GTE Laboratories. We speak only as a pair of concerned working scientists who have witnessed and have been fighting the battle against declining basic research activity in this country.

We would recommend legislation mandating the following changes in NSF Policy toward Industrial Research Laboratories:

1. Earmarking some small portion of NSF budget for support of basic science in industry.
2. Removal of special qualifying criteria on proposals from industry. Within the budgetary constraint, the proposals should be in direct competition with university proposals.
3. Formulation of rules which would result in lowering cost to NSF on research in industry — such as cost sharing.
4. Increased participation of Industrial Researchers in the peer review of proposals.

Under these recommendations, NSF should begin to fund basic research in industrial laboratories. The reasons for supporting this change can be stated concisely:

- It would be good for science
  - The best people, the best facilities and the best ideas should be funded wherever they can be found.
  - NSF could provide long-term stability in basic research.
  - Relief could be provided to a generation of scientists who have been accepted by universities to do basic research as graduate students and post-doctoral students but have been largely turned away by the universities thereafter.
- It would be good for the country
  - If basic research is to be of benefit to society, it must eventually impact industry where new jobs and new products are created. Therefore, basic research cannot be isolated in an academic ivory tower.

- It would stimulate long-term research in industry providing continued vitality in the economy
- It could help reverse the current downward trend in industrial innovation.
- It could help restore our competive edge with other nations who are very effectively funding basic research in industry.

● It would be good for universities

- Overlapping interests could provide channels whereby academic researchers could learn of areas of timely research.

● It would be good for NSF

- NSF can become a true National Science Foundation rather than a parochial club catering to a limited number of academic researchers.

Our position, as we have stated it, needs certain definitions, clarifications, and supporting arguments. Certain myths about basic research and about the National Science Foundation have to be removed. These we address in detail in the main text. Relevant material can also be found in a recent report to the Senate Subcommittee on NSF, entitled, "A Report on Research in Industry; Roles of the Government and the National Science Foundations," hereafter referred to as the NSF Report.

II. Background

a. Public Funding of Research in Industry

Let us first define what we mean by basic research. In a most general sense, any activity caused by curiosity about the Universe and conducted by scientific methods qualifies as basic research. Yet, to anyone even vaguely familiar with modern science, there appear qualitative differences between research problems. Some are definitely more basic than others.

Great extremes exist within the spectrum of work variously referred to as basic research, research and development, and development. The scientific approach and the tools used are quite similar. However, there are great implications regarding funding as one moves from one end of the spectrum to the other.

At one extreme, one has "mission oriented research" involving applied research or device development that can be anticipated to produce an immediate benefit to the organization performing the work (such as a new product) or fill a specific need recognized by the Government. In these cases, the funding should be provided either by the organization or by the Government agency charged with the mission.

At the other extreme is "basic research" on concepts, new phenomena, and feasibility of ideas. Direct application to technology is vague and uncertain. Such work cannot be expected to produce immediate benefits but is essential to long-range technological progress. Pay-off from this type of activity results from an assimilation of similar research by many institutions, including industrial laboratories. It is essential that such research thrive upon free exchange of information in the scientific and technical communities.

It is our fundamental contention that the present scenario where research is to be conducted exclusively at universities, while industry is to provide only applied work, is an artificial dichotomy, inevitably leading to a general decline of overall technological innovation and progress. In our opinion, the effects of these policies are already clearly apparent.

Historically, the leading industrial laboratories have played a major role in maintaning the quality of American Science and have provided the natural channels for maintaining technical leadership: This is a very American phenomenon which has served the country very well. The benefits of "basic research" are widely dispersed; and, therefore, there is a strong case for federal or public funding, even though an industrial corporation is involved.

b. Benefit of Basic Research to Society

We firmly believe that science in general and basic research in particular does benefit society as a whole. However, this benefit to the nation's economy and welfare is often long term and difficult to anticipate while the work is planned and carried out. Many of the decision makers in defense agencies, in corporate organizations, in congress, and even many working scientists faced with exigencies tend to sacrifice long-term goals and relegate basic research to academic scientists. Basic research is important to the country and those who are best equipped in background and facilities should be encouraged (not just allowed) to do it.

It follows that there should be a national agency whose responsibilit, is to oversee the health of science in the country regardless of institutional affiliation, providing guidance and funding. It seems obvious to us that this agency should be the National Science Foundation, and it seems strange to us that NSF does not appear to aspire to this role. For years it has approached the question of funding basic research in industry rather timidly. If NSF really believes in science, it is now time to approach the problem more aggressively. Lack of funds would appear to be a lame excuse. If a case for an expanded role for NSF is built, the funds will follow; but it is long overdue for some institution in this country to act as chief spokesman for basic science. The re-establishment of the Office of Scientific Advisor to the President is a most welcome sign, but this, in our view, in no way relieves NSF from the leading role it should play.

To revitalize basic research in this country researchers in industry should be encouraged to compete for funds. Many industrial laboratories have facilities and personnel that cannot be duplicated elsewhere. Industrial corporations are a national resource important to the present and future economy of the country. Corporate officials, particularly under present economic conditions are too involved with immediate problems to devote a large amount of thinking about basic research. They should receive added short-term inducements to spend more time looking at long-term goals.

There exists a volatility in government support of science which has deplorable consequences for both science and individuals. By broadening its role as sponsor of research (wherever it can be done), NSF can greatly enhance its role as the stabilizing element. The history of the last few years could have been avoided had there been more control planning and less capriciousness. If NSF is to continue to do nothing but support only universities, it will, of necessity, act as a destabilizing factor. What is the point of producing excellent young scientists if there are no jobs for them? Some fraction of this population has to stay in science because this is what they do best and love most.

Not all of them can be reabsorbed by universities. Of those that go to industry, some fraction should be given the opportunity to do further scientific work. We think NSF should welcome and actively seek some responsibility for its own product.

NSF should not by default relegate the responsibility for supporting research in industry to DOD. The political atmosphere is much more conducive to an expanded role of the civilian sector at this time. The argument that such change of policy can only be effected at a greatly increased budget is spurious. In our opinion, the role of NSF should be changed first and an increase in budget will predictably follow. Rightly or wrongly, NSF has often been accused of clubishness and closed shop attitudes. This hurts NSF in the political arena and also hurts science. Broadening its activities, NSF will enhance its stature and become far less open to often irresponsible criticism.

c. Interaction between Universities and Industrial Laboratories

If a closer interaction between universities and industry is a recognized goal, then removal of the present exclusion of industrial labs is mandatory. None of the proposed sabbatical exchanges, etc., will achieve as much as would a broadening of the support base.

The interaction and cooperation of all scientists should be encouraged regardless of affiliation. In principle, sabbatical exchanges between universities and industrial labs is a good idea; but if it is to be effective, a much more stable employment climate must be established. Academic scientists have a tradition of sabbaticals; but under present economic conditions, few industrial scientists would want to admit that they can be spared from their job for a year. This is not a realistic suggestion. Closer interaction between academic and industrial scientists could be achieved if some individuals from each sector work on similar basic research problems, attend the same scientific meetings, and have overlapping day-to-day interest.

III. <u>Should the Status Quo be Maintained?</u>

A reading of the NSF Report, conversations with NSF personnel and members of academic institutions has made us, we believe, thoroughly familiar with the main arguments against any drastic changes in NSF policy.

These arguments are all implicitly contained in the report to the Senate Subcommittee on the National Science Fondation. We wish to repeat them here in capsule form for the purpose of further discussion.

1. <u>NSF is already supporting industrial research through (a) special programs and (b) manpower output of academic institutions. It is questionable whether this support should extend any further</u>.

Assertions (a) and (b) are true although their interpretation is subject to argument. Foremost among the special programs is the brand new Faculty Development Program. Recently a time period of two months (which included Christmas holiday) was given to apply. During this time, a faculty member had to find an industrial laboratory willing to accept him, develop a program of research, write a proposal and obtain a release from his institution. Having witnessed at first hand the herculean efforts of one individual to provide all of the documentation by the due date, we are skeptical of the attractiveness of this program. In any case, industry is only a secondary beneficiary since the program is directed at the development of the faculty member. Nevertheless, programs of this sort are valuable and constitute an admission that there is opportunity for doing first class basic research in industry.

According to data provided by NSF, 4.3 million dollars has been allocated to basic research in industry in 1976. This represents about 1/2 percent of the budget. We have no idea how this money is spent, what exactly it supports and what criteria were used to classify the supported programs as basic research. An inspection of the 1975 NSF listing of Awards and Grants (in the area of Physical Science) has failed to convince us that there are any industrial grants which could be classified as basic research.

Referring to assertion (b) it is true that industry depends for its technological manpower upon trained graduates from universities. We think however that it is a spurious and self-serving argument to claim that this constitutes an NSF support of industry. It can be argued just as persuasively that it is the industry which supports the academic institutions by providing a job market and, therefore, the graduate student manpower to perform the research in universities. In addition, industry pays taxes from which NSF budget derives.

It is our contention that NSF pays little attention to the fate of graduates once they leave the University and to the existence of jobs for which they were trained. Since the universities are not hiring and there is little opportunity to conduct research in industry, these graduates must feel exploited. By denying them the opportunity to obtain grants for further research, NSF is contributing to the waste of talent and skill which it prides itself of creating in the first place. We consider the use of this argument rather cynical.

2. One cannot allow a dilution of funds in support of universities.

It is absolutely true that any substantial dilution of support for academic institutions would be against national interest. We are far from suggesting anything which could be interpreted as a withdrawal of support from universities in favor of industry. To clarify our position we suggest that:

First - an attempt should be made by NSF to increase its budget specifically for this purpose.

Second - a very small fraction of the overall budget (probably no more than 5 percent) should be used for this purpose.

Third - in cases where the industrial proposal is clearly superior to some university proposals there is a valid reason for funding the former in lieu of the latter if the objective is support of best Science. Support of inferior projects cannot in every case be redeemed by educational or didactic values. The exclusion of the individual best performer, just because he is affiliated with an industrial laboratory appears to us to be against the original mission of NSF.

Fourth - it is, we think, a myth that NSF will be deluged by very high quality proposals from industry. Most industrial labs have pressing needs and may not be able to spare personnel for doing basic work even when it is partially supported. Others may find it against their interest to enter into agreements which may jeopardize their proprietary position.

Since traditionally NSF likes to link its support to individuals rather than institutions (as long as they are academic), we suggest that it extends the same opportunity to the individual from industry who can persuade his (hypothetically cool) management of the wisdom of applying for an NSF grant.

3. Research performed at universities is a "better buy" because of the much lower cost.

This is undeniably true. There is no way that industry can compete with the universities on a cost basis. However, important research topics are often "brain waves" of individuals and as such cannot be open for bids. If the idea is good and promising and if there is no equivalent research proposed by universities, one may have to pay a higher price for a superior product.

However difficult it is to quantify the cost of first-class research, the problem of lowering the cost of work performed at industrial institutions still remains. The NSF Report addresses itself to this problem and recognizes the need to remove disincentives. The role of NSF is obviously limited to a study of the problem and the dissemination of information among the branches of government which can deal with it by say, altering the tax laws.

We suggest that there is another avenue, much more direct and entirely within NSF's power to enact. The cost (to NSF) of industrial research can be substantially reduced by insisting upon cost-sharing of a project. At a level of "fifty-fifty" sharing, the industrial and academic costs would tend to equalize. We suggest that at that level industrial management may still see it as a substantial inducement for providing matching funds.

Some of the value of basic research for industrial management derives not only from its results but also from its attractiveness for a certain type of individual. Some industrial laboratories have recognized this problem by bestowing special status to exceptional individuals, others have used it in recruitment or advertising. Basically the same forces are at work which make some academic institutions more prestigious than others. If the result is an upgrading of the work performed, we claim it is a good investment for both industry and government.

4. Industry may abuse the grants by either withholding results or using them to private advantage.

This is a complex problem, fraught with many misunderstandings. We cannot analyze it here in full but only offer some hopefully relevant comments. First, from long personal experience, we can unequivocally claim that companies encourage (and in some cases offer financial inducement) for the publication of research results. It is sufficient to glance through major scientific journals of ten years ago to see that roughly one half of the publications originated from industrial institutions. Today this has dwindled to a very small fraction.

Second, there are natural corrective forces which operate. Any company which would abuse its contractual agreements with NSF would lose its chance for any future support.

Third, even if the company does derive some benefit from the research, we do not regard this as evil provided it is done openly. Likewise, we do regard it as nationally beneficial that many high technology and profitable industries have originated as spin-offs from university research that was carried out on NSF grants.

Fourth, the area of patents, licensing, etc., is one that deserves careful consideration but which should not be used to stifle technological progress financed by the Government. An excellent exposition of this problem is contained in the article by E. B. Staats, Comptroller General of the United States, appended to the NSF report. In the last analysis research dollars coming from DOD, ERDA, or NASA are as much taxpayers dollars as those dispensed by NSF. It seems to us that the morality of conducting basic research in profit institutions at taxpayer's expense is of equal if not higher order. The acceptance of the idea is one which NSF is superbly destined to foster.

87-769 O - 77 - 16

IV. Conclusions

We believe that the arguments which we have presented in this testimony call for an expanded role of NSF in support of basic research in industry. In making this recommendation we find ourselves in essential agreement with the NSF-Industry Task Force Preliminary Report to be found on page 11 of the NSF Report. We find ourselves in serious disagreement with the position taken by the National Science Board, defining the official position of NSF and contained in the same Report — pages 1 through 10.

We hope to have contributed to the opposing points of view in a manner which will result in legislation broadening the scope of NSF in supporting basic research in non-academic institutions.

V. Biographies

A. Lempicki

Born in 1922 in Warsaw, Poland. During the second world war, member of the Polish underground "Home Army." 1945-1946 Second Lieutenant in the Polish Corps in Italy (under British command). Married in 1952, two children.

B. Sc., Imperial College of Science and Technology, London, 1949.

M. Sc., Imperial College of Science and Technology, London, 1952.

Ph. D., University of London, 1960.

Major graduate work: physics.

After graduation, Dr. Lempicki joined staff of EMI in High Wycombe, Bucks, England. He worked on the design of vacuum tubes and solid state devices from 1949 to 1954.

In 1955 he emigrated to the United States and joined the Staff of Sylvania Research Laboratories in Bayside, New York. Upon acquisition of Sylvania by GTE, he remained with the GTE Laboratories and eventually transferred from Bayside to Waltham, Mass. in 1972.

From 1964 to 1972, he was Manager of the Quantum Physics Group and presently he is Manager of Electro-Optics Laboratory, Special Projects Office. His professional activities included research in luminescence and electroluminescence with emphasis on optical and electrical properties of single crystals of the sulfides; research on luminescence of organic materials and organo-metallic complexes; spectroscopy of rare earth ions in crystals and liquids; research in quantum electronics, in particular on optical laser action in liquids; light scattering in liquids. He has published approximately 70 scientific papers and holds 11 United States patents.

From 1969 to 1972, he was a consultant to NASA office of Advanced Research and Technology. He is a Fellow of the American Physical Society and a Member of the Optical Society of America.

A large fraction of Dr. Lempicki's scientific research was done under Government contract, mostly sponsored by DARPA and the Office of Naval Research.

E. J. Johnson

Earnest Johnson was born in 1931 in the town of Philipsburg in the soft coal region of Pennsylvania. He was married in 1956 in Los Angeles, California; he currently resides in Lexington, Massachusetts, with his wife and eight children.

Dr. Johnson received the B. S. degree in Physics at The Pennsylvania State University in 1953, an M. S. degree from Purdue University in 1954, and a Ph. D. in solid state Physics from Purdue University in 1964.

He conducted applied research in semiconductor devices at North American Aviation in 1955-56 and at Hughes Aircraft Company in 1956-58. His research at Purdue involved basic studies on the optical properties of semiconductor materials. He continued this work with magneto-optical studies at MIT Lincoln Laboratory. This basic work provided knowledge of significance in semiconductor technology, and he has written a review of the subject in a reference volume on the basic properties of semiconductors.

In his later work, he has concentrated in studies of lasers, laser materials and exploitation of new laser phenomena. Since 1973, he has continued this work at GTE Laboratories in Waltham, Massachusetts.

Dr. Johnson has numerous publications in the various fields he has worked, is a member of the American Physical Society and the Association for the Advancement of Science.

Dr. IBERALL. For the sake of the record, I would point out to Dr. Barger that there is an American Association of Small Research Companies. BB&N and we are competitors, I can assure you of that—for example in a coustics. We are not co-conspirators, but our statements, strangely enough, are completely complementary.

My name is Arthur Iberall. My training is in physics and mechanical engineering. My background is in Government and industry. I am the chief scientist and president of General Technical Services, and I have a 10 minute oral presentation.

The thrust of my remarks is that if you want to consider a role for industry within NSF, you have to go back to basics. For this, I would start from NSF's history.

There was one basic issue that led to the conception of NSF. It was whether a centralized Government agency devoted to the basic research needs of society was needed. It was to the singlehanded credit of Senator Kilgore and his indefatigable aide, Herb Schimmel that the attempt was made to capture that notion in legislation. Unfortunately, as part of the task of achieving acceptance of the goal, attention was diverted to the support of academic institutions for their academic scientists.

It is my purpose to give you some brief versions of the themes that led to NSF's formation, and the current, still very present, consequences for NSF policy and the needs of the Nation.

A more official history was offered by Detlev Bronk and J. England.[1]

I would urge this committee to avail itself of the testimony of Mr. Schimmel. His cognizance of the undercurrents involved in NSF formation exceeds anyone else's and these currents are still with us.

Science, in my view, is confronted by only one basic problem, and that is, how to understand that which is inside and outside of us, so that we may be better able to understand and govern that which is inside of us. It is interesting to note that this is the same central problem that confronts religion, philosophy, and politics.

It is also interesting to note that in times of crises, when societies are well enough off to support their immediate needs, but require expansion of their world horizons, that the significance of coupling science and society occurs to national leaders. This was true in the Greek city-states, the Mediterranean city-states and the Renaissance, and the European politics in the Enlightenment.

We have been facing reformation of society, by means of new orders and new relations as the aftermath of World War I. The Great Depression, World War II, the current national and international crises, are continuing parts of that adjustment among nations of all ideologies. No one of them has the answers. So, once more, we may consider turning to science.

One major impetus to the current Government interest in science was former President Roosevelt's queries in the 1930's—what can social institutions, business, labor and so forth, do for the reformation of an ailing society?

It is not so well remembered, that this question was also directed to science and technology, and it was a result of Kilgore's congressional concerns, inquiring into the operations of the economy, that turned his

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[1] *Science*, May 2, 1975; January 9, 1976.

particular interest to the possible contributions of science in the 1940's.

An official story relating Bush and the NSF states: "Since 1942, Kilgore had introduced and held hearings on bills to mobilize science and technology for more effective prosecution of the war and for application of science to national problems when peace came." "Bush strongly opposed those bills and he also tried to guide Kilgore toward more acceptable measures." "Bush thought that the Senator was honestly trying to get at the root of the matters, although some of the people about him steered him into strange paths."

Those people steering Kilgore with strange ideas represented a considerable fraction of the interested parties that Schimmel worked through in trying to develop an interest in a charge for a national science institution.

There were those who were against the idea. For example, some thought it would infringe on industrial R. & D., and industry's ability to develop proprietary scientific ideas. Others thought it would infringe on the charge of many existing Governmental laboratories. Academic leaders thought that it would compete with their academic interests in pure science. And some simply thought it was impossible, or certainly premature, to attempt to develop a coherent science theme, and least of all, within Government.

Those who were for the idea were divided. Some people in the industry thought that it was a good idea to provide industry with a basic science pool of ideas that did not have to be competitive with a more applied R. & D., and some people in Government thought that it would serve as a central science pool to which less mission oriented problems could be referred.

Bush and his supporters, ultimately took on the view of regarding it as a potential foundation to offer financial support for gifted academic scientists to freely pursue scientific notions that they considered significant.

One can surmise the upshot—Kilgore and Schimmel had a hard time. A political constituency for science, whether for society or not, had to be found, and so they had to dilute and compromise their notions to get active scientific, particularly academic, support.

Meanwhile, whenever the battle for the foundation lagged, end runs were tried to get the main task of science applied to social needs installed at the Bureau of Standards. The Navy, perhaps realizing the real significance of mission oriented science, quietly pushed the Office of Naval Research through, and for most of its life, ONR has largely hewed to developing the essential R. & D. that its divisions considered necessary under a general Navy policy.

In the post war euphoria, it appeared that at least partial victories for science had been won. The Navy had gotten ONR, a civilian control of atomic energy was achieved, the National Science Foundation Act was passed, and Bush had gotten his "Science, the Endless Frontier" message across. Consider the latter two.

The quest for a national science center and Bush's quest to put across his message were not one. When Bush's message came across, there was a reasonable number who understood its impact. It wasn't clear how far he could sell it. The response was mixed, pro and con. Among responses in journals of the day, there were those who considered the message as a call for unfettered science, as an endless boondoggle. It was thought that too much was promised and that it had no responsibility to its social paymasters.

When NSF legislation was finally passed, it appeared that the science for society goal was won with reasonable political control. It appeared that NSF would be designed to tackle significant problems of national concern. It might have been expected, perhaps by the course that we had been accustomed to at the Bureau of Standards where I worked at the time, or NACA, and in fact, as it emerged within ONR, that NSF would make use of transferred funds and best efforts contract or grant research on major problem areas of concern to the Government, as defined by statements of work from NSF personnel.

We anticipated that the major problem was for NSF to define a national science program, and to reconcile its science mission with the mission directed pieces of other departments of the Government.

Thinking that the institutional battle was won, there was no follow through from all those who should have been involved, whereas early NSF leadership followed through on its elected path. Busy scientific people simply did not have the time nor the inclination, to review again and again, what could be regarded as academic efforts to investigate limited problems. They would have expected that appropriate review judgments would be a function of knowledgeable personnel within NSF acting within specific public charges.

But, the academics did have such time, and in time, they developed their outside peer review system, which, by use of their time, brought them economic security, thereby putting themselves in the position of eliminating competition from outside of their circles.

I must confess to an inability to grasp that outlook as a suitable guiding principle within our society, although in The Affluent Society, John Galbraith describes very well why groups in our competitive society, quickly, "set about eliminating competition as it effects themselves."

Now, this brings me up to the message that I have learned since 1950.

First, at the NBS, where I worked, we had to compete vigorously for scientific-technical funds. There were few guaranteed resources. Thus, within my former section——

Senator KENNEDY. Let's focus in on the problem here.

I think the history is important for us, but we are trying to find out whether this is important to industry and what we can do about it. This is what we hope to get some ideas from you on, in these final few minutes here.

Dr. IBERALL. I think my comments at this point will illustrate the problem that faces us in small business R. & D.

At the Bureau, our problem was transferred funds in doing the science needed, and that proves foolish for NBS security.

Senator KENNEDY. Why do you not just tell me, off the cuff, now—I am a layman, and we are all lay people here. You have to lay it out for us, now.

What do you want, what do you need—what's the potential, what are the problems?

Dr. IBERALL. Let me make the next point and then I will address the subject.

Senator KENNEDY. Well——

Dr. IBERALL. When I went into small business R. & D., and thought that I only had to do a job cheaper, faster, better than my competition, that proved to be nearsighted. As time went on, my competition, with essentially all the classical monopolistic devices, have frozen us out. Competition in R. & D. is from the large universities, the large aerospace corporations, the not for profits, and the large for profits. It is not their size, technical know-how, nor their sales forces, which bothers us. It is the suspension of what had once been normal modes of competition. Their preferred instrumentality role, via peer reviews, study commissions, panels and councils, selection by cronyism, their high mobility in which no conflict of interest is seen, is what defeats us. We happen to be back to Kilgore's original concentration of power interests.

The problem, if I may drop all the rest of remarks for the written record, is that science for a society is a needed function. It requires all those who have competence in these scientic areas to have access, in a free, competitive fashion, to those funds in Government funding sources such as NSF and NIH.

We, in industry, particularly small business R. & D., are excluded from contributing our part. That would be the essence of my message to you.

Senator KENNEDY. Yes, but then how do you deal with it? That's what my problem is, how to deal with it.

Dr. IBERALL. I address myself to that issue in my written testimony. As Dr. Barger indicated in the first place, there is absolutely no reason, there was no reason from the very beginning, that NSF could not permit us to participate as an industry, or anyone else, for that matter, to address significant problems that either we or NSF suggested.

Senator KENNEDY. All right.

Now, Dr. Barger, what—how do you answer the question that—why does the industry not—or why can you not get the possible from the profits of the various companies, corporations? Why are they not sufficient to deal, to carry this on? Why do you need NSF grants?

Dr. BARGER. That is the nub of the problem, and it is the reason why I distinguish between research and development services industries and industries represented by the association that Mr. Iberall referred to.

This group that I'm describing has, as its primary business, its raison d'etre, contract research and development. The other larger class of institutions in this country that have, as an important component of their activities, contract research and development, are universities, not for profits, and so on. But, there is also this R. & D. services business component that is competing for these funds as well.

These R. & D. services companies demonstrate quite often, and I gave three examples, important industrializations and commercializations, of their ideas, and that is about as far as it goes. In other words, it often takes the other—the bigger, manufacturing industries to establish the new business. They see a small commercial demonstration, and then they emulate it. With the management talents and capital that they have, they expand the new business very rapidly from that point. But it is getting from the basic idea to the demonstration, so that the big industries can see it working and say, ah ha, so that is how it is. And sometimes they hire one or two of the people from that R. & D. services company as one of their vice presidents and set up a new division, to make an industry out of it. This happened in the cases that I described on time-sharing computers.

But, the primary interest of these people is to bring it to the demonstration, and then they go back and they get interested in another basic research project. Because they are basic-research trained scientists, who are motivated to take their ideas farther—farther than scientists normally are motivated to take their ideas in a university setting—as far as a commercial demonstration. And I say that is the nub of technology transfer. I think that is where this group of industries differ from other industries, and from universities, and——

Senator KENNEDY. Well, why can you not use profits to invest in additional research where you think it is necessary?

Dr. BARGER. One does.

The retained earnings of an organization that has been in business as long as ours get bigger every year. But they get big at less than half as fast as they would in an industry that was not paying taxes, but they do increase. And these companies do fund basic research within themselves on their own money, but not much.

What they prefer to do, Senator, is to fund the commercial demonstrations. That is what they do with their profits, and they go back to their traditional sources of basic research funds to initiate the process.

And, I think this is a very unique way of operating. I do not know how it evolved. It has proven itself. I think it should be considered very seriously in this technology transfer problem.

Senator KENNEDY. Right.

Dr. Johnson.

Dr. JOHNSON. Yes.

I think this is a very important question.

In my written material, I go into great detail to describe what I call the spectrum of research and development. There are wide extremes in the spectrum and there are great implications regarding funding.

There is, at one end of the spectrum applied research. The results of which can easily be predicted. It may be obvious that this work is going to result in a sellable product. Industry obviously should, and they do finance out of profits, such research.

Now, what I have been addressing myself to is basic—well, long term, research on concepts, basic ideas, feasibility of ideas, understanding, et cetera. In this case, the direct application is often vague and uncertain. There are no immediate benefits. However, such research is essential to long-range technological furtherance.

Senator KENNEDY. All right.

Now, just on that point, is industry, then, interested in those types of research?

Dr. JOHNSON. Yes.

Yes, they are.

Historically, you go back 10 years—they were extensively funding research of this type, and some are still trying. Economic stresses have been present—have been widespread, in corporations, in universities, in the Federal Government, and these economic stresses have had their effect—have created their damage.

A lot of people, a lot of management, is trying their best. They are trying their best. But they need help. And since the payoff from basic research results from an assimilation of similar work from many institutions, including industrial laboratories, there is a community aspect.

The industrial corporations are a natural resource—a source of jobs for the economy, and therefore, it is important to the country as a whole, that such long-term technological progress be stimulated and done.

Senator KENNEDY. Well, let me ask you as a follow up—where is the venture capital applied to this? How do you address the argument that this research has potential and advantages over the long term. Why is there no venture capital available and why should the NSF step in?

Dr. JOHNSON. Well, the venture capitalists, as I understand it—I'm not that familiar with their activities—they are interested in funding things that have already been demonstrated. They are interested in a short-term profit.

Now, often, though, the basic research is done in one place and the pay off occurs somewhere else. The example I can give is the transistor. A large amount of the basic research was performed at General Electric Laboratories at Purdue University in the 1950's. The—and late 1940's—but who was it that came up with the invention of the transistor? It was Bell Labs, so you may—one laboratory may do extensive basic research, the long-term basic research, but the pay off may occur somewhere else.

Senator KENNEDY. OK.

Dr. BARGER. Senator, your question about venture capital is an important one, and I was only leaving that out of one of my examples for brevity, the first time.

In the third example I gave, the packet switched computer communications business resulted from basic funding by ARPA, which is the Advanced Research Projects Agency of the Department of Defense, and was demonstrated there in the ARPA network. The question was, how can we start a commercial industry?

People say venture capital has become unavailable, but that is not true. We obtained a major venture funding for Telenet Communications Corp. from venture capitalists in 1972. I believe that we were about the only ones to obtain significant venture capital in that year. This is part of the point I was trying to illustrate.

The basic researchers who are trying to push these ideas out the door are trying so hard they will even succeed in getting their own venture capital, because indeed, the services companies that I am talking about have not got large cash balances. Three percent is all you can obtain on sales on a research contract, after taxes and the cost of capital. So, this group of companies has sought and obtained the venture capital to fund the further commercialization of its own ideas.

Senator KENNEDY. Let me ask the panel—is it true as has been suggested that many of the youngest, brightest, and ablest young scientists, who are outstanding at universities, are coming into the private sector?

Is that something that you have noticed?

I'm interested in finding out whether that is so.

Dr. IBERALL. What one finds going on in most of the technical professions today is that the academic point of view is undergoing very great changes, particularly in the sciences. There is a growing concern that there is a loss of opportunity within academia. So one now finds that most of the technical societies, and scientific societies, are trying to figure out some way to indicate to their academic oriented young people, what industry might have in the future for them.

Senator KENNEDY. Do you have any additional comments?

Dr. JOHNSON. Yeah.

Some of them are going nowhere. Some of them are just giving up. There always was some young people—some very good people, who chose industry over universities because that is where their interests lay. But a lot of others are going into industry now where their first choice was the university and many of them whose interests are in more stimulating, more basic type work, find themselves doing work they do not find that challenging and do not find that creative.

Senator KENNEDY. All right.

Dr. Barger?

Dr. BARGER. The assertion is true, and I am not sure whether the younger men are coming into industry because of financial constraints or whether it is because they seek this mix of basic research and problem oriented research, being conducted there. I'd like to think it is the latter, but I suspect there is a strong component of economics.

Senator KENNEDY. But there is an interest—and I want to be sure I have it on the record—in industry in basic research? There is an interest in competing and competing on a basis of which can benefit the country's interest, I know all of you nodded before or you smiled. I want to make sure I get it on the record.

Dr. JOHNSON. It is on the record, and I would like to comment in a little more detail if you would like.

Senator KENNEDY. Just briefly, please.

Dr. JOHNSON. OK.

Well, my comments are that the interest varies from industry to industry and company to company.

As I've said before, I cannot officially speak for my own management, but my own opinion gathered from associations with laboratory managements is that, yes, they would like to—they are doing some now, they would like to do more, but as I said before, they need help.

I think the real question is: "Should they be interested? Should they be concerned? What is happening to innovation in industry?"

There is an example of the steel industry who is not known for doing much in the way of research, but of course, what I understand now, about the steel industries is that they are now having a hard time competing with foreign steel industries that are using new and innovative processes.

I have already mentioned the optical communications industry—which shows prospects of revolutionizing the telephone industry.

You look on the pages, as I have already said, of the Journal of Applied Physics; here you find that most of the authors are Japanese.

Now, a side comment on this question is that if NSF thinks that the perturbation on NSF—if the industrial interest is small, which I do not think it is, then the perturbation on the NSF budget would be likewise small, and those few, if it is few, who are really interested, will then have the opportunity to participate in the NSF program.

Dr. IBERALL. Now, if I may add a final comment on that—industry in general is not interested in basic research and never was, and there is no change in that status.

On the other hand, appropriate to your question to the earlier panel, there is a small group, a small industry of people, and there has always been, who are concerned with the basic R. & D. For applied needs and in a certain sense, the panelists who you see in front of you represent the interest or the point of view of that group.

Senator KENNEDY. Dr. Barger?

Dr. BARGER. Yes.

Just to make it perfectly clear, there is a group of industries that is vitally interested in basic research. It is vitally interested in receiving support to do it.

The important thing this industry has demonstrated is the ability to transfer basic research to demonstrations of new businesses and services. This segment of industry is vitally interested in basic research funding.

Dr. IBERALL. And the ability to compete in both science and technology.

Senator KENNEDY. OK.

That was very informative.

We will be staying in touch with you on this issue.

Thank you very much

[The prepared statement of Dr. Iberall, accompanied by additional material, follows:]

Statement - A. S. Iberall, chief scientist and president
General Technical Services, Inc., Upper Darby, Pa. 19082

To the Senate Hearings on National Science Foundation
March 3, 1977

NSF and the National Interest

There was one basic issue that led to the conception of NSF. It was whether a centralized government agency devoted to the basic research needs of society was needed. It was to the single-handed credit of Senator Kilgore and his indefatigable aide, Herb Schimmel that the attempt was made to capture this notion by the formation of NSF. Unfortunately, as part of the task of achieving acceptance of the goal, attention was diverted to the support of academic institutions seeking a new role and financial support through their academic scientists via an unfettered search to satisfy their intellectual curiosity. The basic needs of society received short shrift. It is my purpose, in this statement invited by your committee, to give you some brief version of the themes that led to NSF's formation, as I was familiar with them, and the current still very much present consequences for NSF policy and the needs of the nation - for its people, industry, Government, and the educational establishment.

An 'official' history may be found in Detlev Bronk's and J. England's statements in Science (May 2, 1975, January 9, 1976).

I would urge this committee to avail itself of the testimony of Mr. Schimmel. His cognizance of the currents involved in NSF's formation exceeds every one else's. These currents are still with us.

Science, in my view, is confronted by only one basic problem - how to understand that which is inside and outside of us, so that we may be better able to understand and govern that which is inside of us. It is interesting to note that this is the <u>same</u> central problem that confronts religion, philosophy, and politics.

It is/also interesting to note that in times of crises, when society is well enough off to support its immediate needs but requires an expansion of its world horizon, that the significance of coupling science and society occurs to national leaders. This was true within the Greek city-states in their golden age after their Persian victories, within the Mediterranian city-states in the Renaissance after they had settled with Northern, Eastern, and Southern invaders, within the European polities in the Enlightenment after they had established nation status and had begun their age of exploration for external empire.

We have been facing reformation of society by means of new orders and new relations as the aftermath to World War I. The Great Depression, World War II, the current national and international crises are continuing parts of that adjustment among nations of all ideologies. No one of them has the answers. So once more we may consider turning to science.

One major impetus to the present Government interest in science was former President Roosevelt's quiery in the 1930's. What can social institutions - business, labor, etc. - do for the reformation of an ailing society? It is not so well remembered that this question was also directed to science and technology, and it was a result of Kilgore's Congressional concerns inquiring into the operations of the economy that turned his interest to the possible contributions of science in the 1940's.

An official story relating Bush and the NSF (Science, January 9, 1976) states: "Since 1942 Kilgore had introduced and held hearings on bills to mobilize science and technology for more effective prosecution of the war and for application of science to national problems when peace came." It points out that "Bush strongly opposed those bills, but he also tried to guide Kilgore toward more acceptable measures." It notes that "Bush thought that the Senator was 'honestly trying to get at the root of the matters', although 'some of the people about him steered him into strange paths'."

Those people 'steering' Kilgore with strange ideas represented a considerable fraction of the interested parties that Schimmel worked through in trying to develop an interest in a charge for a national science institution.

There were those who were against the idea. For example some thought it would infringe on industrial R and D and industry's ability to develop proprietary scientific ideas. Others thought it would infringe on the charge of many existing governmental laboratories. Most academic leaders thought that it would compete with their academic interests in pure science. Some simply thought it was impossible, or certainly premature, to attempt to develop a coherent science theme, and least of all within Government.

Those who were for the ideas were divided. Some people in industry thought that it was a good idea to provide industry with a basic science pool of ideas that did not have to be competitive with a more applied R and D. Some people in Government thought that it would serve as a central science pool to which less mission oriented problems could be referred. Bush and his supporters ultimately took on the view of regarding it as a potential money dispersing foundation to offer support for gifted academic scientists to freely pursue scientific notions that they considered significant.

'Rashamon' - Another Man's View of History

I can briefly indicate my bias and interest in that spectrum of response at that time to Kilgore and Schimmel's efforts to develop support for a science bill. As a young physicist at the National Bureau of Standards and an activist within a CIO union trying to organize scientists and engineers, we were concerned parochially with ending discrimination in the District, full employment in a post war world, a scientific future for the National Bureau of Standards, a reasonable world order, and later civilian control of atomic energy. Obviously Roosevelt's social-intellectual leadership cast the image. In that milieu we wrote a Post-War Program for the National Bureau of Standards during World War II, and in attempting to get support for our program, we got to know Schimmel.

We had divided loyalties. On one hand we wanted a major charge for our bureau, the NBS. On the other hand we knew the entire detailed story of the internal timidity of our agency. We therefore had to become enthusiastic supporters for Kilgore's vision. Schimmel was a fantastic organizer. He breezed through all technical - academic - Governmental - Congressional - industrial - societal circles in his singular minded quest to get a problem oriented national science agency organized.

One can surmise the upshot. Kilgore and Schimmel had a hard time. A political constituency for science, whether for society or not, had to be found. They had to dilute and compromise their notions more and more to get active scientific, particularly academic, support.

Meanwhile whenever the battle lagged, we kept trying end runs to get the main task installed at the Bureau of Standards. The Navy, perhaps, realizing the real significance of mission oriented science, quietly pushed the

Office of Naval Research through. And for most of its life - until the 70's - ONR has largely hewed to what NSF should have been doing, namely developing the essential R and D that its Divisions considered necessary under a general Navy policy within a mission oriented governmental charge. It is difficult to say the same for the later DOD groups - AFOSR and ARO.

And in the post war euphoria, it appeared that at least partial victories had been had. A dent was made into discrimination in the District, a full employment act was passed, civilian control of atomic energy was achieved, the Navy got ONR as a basic research mission oriented science bureau, a National Science Foundation Act was passed. And Bush had also gotten his "Science, the Endless Frontier" message across. Consider the latter two.

The quest for a national science center, and Bush's to put across his message were not one.

When Bush's message came across, there was a reasonable number who understood its impact. It wasn't clear how far he could sell it. The response was mixed, pro and con. Among journal responses of the time, there were those - with whom we were in agreement - that considered the message as a call for science as an endless boondoggle. We then felt, and still feel now, that too much is promised. We felt that it had no responsibility to its social masters. We certainly had no idea of or sympathy for a WPA giveaway.

Fighting against the original academic negativism, it also appeared that the science for society goal was won with reasonable political control, when NSF legislation was finally passed. Namely we were under the impression that NSF would be designed to tackle significant problems of national concern. We expected, perhaps in the path that we had been accustomed at the Bureau of

87-769 O - 77 - 17

Standards, or NACA, and in fact as it had emerged within ONR, to be confronted by transferred funds and best awards contract research on major problem areas of concern to government, as defined by statements of work from NSF personnel.

We thought that the major problem was for NSF to define a national science program (We had only tried a small piece for NBS); and to reconcile its science mission with the mission directed pieces in the various departments of Government - e.g., NBS, David Taylor Model Basin, Naval Research Lab., Beltsville, Wright Patterson Base, etc.; - in government we had been accustomed to consultation and collaboration (and competition).

Having thought we had won an institutional victory there was no follow through. The early leadership in NSF followed through in its selected path. We weren't bright enough to pay attention. For example in early days, I was a reviewer for NSF and NIH, but after awhile I asked to be taken off. I simply did not have the time nor the inclination to review again and again what I regarded as sophomoric academic efforts to investigate the same problem again and again. Such rejections I expected to be the function of knowledgeable NSF personnel. If they had some difficult questions they could consult me.

But the academic did have such time, and in time, he developed his outside peer review system, which, by the use of his time, bought him scientific security.

The thesis, which I could not grasp then, and still do not grasp, is explained by John Galbraith in The Affluent Society, Chapter VIII on "Economic Security". He states: "Few matters having to do with economic life have been so much misunderstood as the problem of economic insecurity".

He points out, "In the world of the competitive society, such insecurity was inherent."

"However, this insecurity, valuable though it seemed in principle, was cherished almost exclusively either in the second person or in the abstract.

"In the conventional wisdom of conservatives, the modern search for security is regularly billed as the greatest single threat to economic progress." While "Among liberals the prospect of finding new forms of social protection with wide appeal to the masses remains the highest hope both for social progress and for political preferment."

"The first step in penetrating this bedlam is to recognize that while risk was indeed inherent in the economic society of the central tradition, it has long been regarded with equanimity by almost no one. And all who were subject to insecurity sooner or later set about eliminating it as it affected themselves." He comments wryly, "The elimination of economic insecurity was pioneered by the business firm in respect of its own operations. The greatest source of insecurity, as noted lay in competition and the free and unpreditable movement of competetive market prices." You may consult Galbraith for more details.

This brings me up to the messages that I had learned since 1950.

1. At the NBS, we had to compete vigorously for scientific-technical funds. There were few guaranteed resources. Thus, within my former section's charge, we were much too busy seeking out Navy, Air Force, Weather Bureau, ONR funds and doing the science they needed to have too much idle review time. That proved foolish for NBS security.

2. When I went into small business R and D and thought that I only had

to do a job cheaper, faster, better than my competition, that proved to be near sighted. As time went on, my competition - with essentially all of the classical monopolistic devices - have frozen us out. Our competition in R and D are in the large universities, the large aerospace corporations, the not-for-profits, and the large for-profits. Consider competing every day with MIT, G.E., Batelle, Rand, and A. D. Little. It is not their size, their technical know-how, nor even their sales force, which bothers us. It is the suspension of what had once been normal modes of competition. Their preferred instrumentality role - via peer reviews, study commissions, panels, and councils; their high mobility in which no conflict of interest is seen - is what defeats us. We are back to Kilgore's original interests.

3. When we became involved in consulting R and D-for-profit, we could sense that control of big science was open until the mid 1950's. Then academia moved into the role. NSF, NIH and DOD provided them both with seed money and opportunity for bootstrapping operations to large sums - institutes and the like. Similarly big development was taken over by the large aerospace corporations. Thus we were told in the mid-60's by our industrial clients, "We don't need you. We can get academic R and D cheaper, with greater prestige, and we get to keep the slave labor that has already been especially trained for us." We watched the price of major academic departments in prestigious schools go up from $6,000 per year Government support in early ONR days to $100 million per year support in the 60's. The NRC and NEC are loaded by the department recipients of such monies.

4. Meanwhile we have grown in technical competence - one either grows or atrophies. We could almost single handedly grasp most of the scientific

problems of concern to society. Thirty five years of attention miss very few. There aren't that many. Parenthetically, we make no claim that we could embrace all the engineering problems. There are simply too many. Thus in 1957, when we were able to outline a "Philosophy for Mid-Twentieth Century Man", we could also attempt to present a "Science for Society" proposal to NSF. Foolishly we thought that NSF was open for themes of national significance. By that time, in our own research directing experience, we were ready to begin scientific generalizations and attacks on large scale scientific problems. It is interesting that our approach was through the assistant director's office. His small NSF staff did not see how a small R and D firm could do a "science for society" piece. Coincidentally, it could see such a study by A. D. Little a short time later. That was the first time that I really learned that our efforts more than a decade earlier had been diverted. NSF was not in business to do science of national concern, but to support a particular frame of scientists.

That particular story doesn't have a completely unhappy ending. It took us some time, in fact 5-7 years, but we finally sold the project to DOD in the Army Research Office - Washington (not Durham, which is an academic oriented program). Since the Army is concerned with 1/13th of the nation's problems, and we were told to stick to the quarter of science occupied with the physical sciences, we regarded our study as "Part of Science for Society, or Science for 1/52nd of a Nation". Our report was entitled, "Advanced Technological Planning for Interdisciplinary Research". (I have appended a short segment from that 1965 study.) Our project officer, Dr. Richard Weiss, Deputy (civilian) Director of Army Research clearly and often indicated to the Army Research Council that the place of that report was as a companion piece to the Army Research Plan. We regarded it and still regard it, as a first such staff document that should be reviewed and rewritten every 5 - 10 years. We recommend that thought to any interested government official. But, note, there was no room for such studies at NSF.

5. In subsequent years, each number of years after we forget the discomfort of approaching NSF, we have come back to them. Why? Because we continue to develop major material of significance to national interests. We know that other narrower mission-oriented agencies will not take on the tasks we propose, and NSF is the plausible place. Some examples of our topics - systematic materials development to meet broad engineering specifications, systematic biological study, water resources study, ecological study, economic study, general systems study. In each case our proposal was not to do something that had been done before, but to open a new avenue of attack on major fields, that neither academic nor large commercial nor nonprofit organizations had thought of or developed. Most often these were fields we had originated in before MIT, G.E., Batelle, Rand, and A. D. Little had even dreamed of getting into. Our most common review critique was that as small business R and D we were not competent to do the task.

6. Now the fact is we were ready in the mid 40's, the mid 50's, the mid 60's, and the mid 70's, each decade with increasing depth, to write the outline of a national science program and to undertake most of its pieces. The first task of writing is cheap, and can be done quickly. The second is a much larger task, and we are not volunteering for it. There is an R and D size that suits our skills. This we are willing to do and are competent to

do in different forms - in industry, in Government, in academia. It amounts to directing a significant fraction of a million dollars of R and D per year. It is that task that we have been doing since 1946. But there are very specific pieces that we know we are uniquely competent to do. And from a national point of view at least one major task that we want to do is highly important. It is to produce a general science of complex systems - of nature, life, and society - and to flesh out as many pieces as we can to guide scientists, engineers, administrators, executives, politicians, in the management of society's interests and needs. It has been an obvious task for NSF. Ridiculously, we cannot sell this at NSF nor at any other agency of Government or society. That science, or more particularly interdisciplinary science, really has relevance to society's problems but is still not a saleable commodity. It still awaits a Prince.

I have only burdened you with this personal story because my interests in a small way mirror what have to be the national interests, and in particular in the field of science, NSF's interests. It is my basic assertion that NSF has diverted the national concern and need for science, in its broad perspectives to serve a narrow constituency of academic institutions, and scientists.

Summary - The Problem Facing Us

The issues we faced in the 30's, and the 40's, and in the 70's have the same roots.

There are no endless frontiers - there are only needs and missed opportunities to get on with the job of making it possible for all to live and to contribute creatively to the common and individual welfare - in expanding times or in bad times.

This time again we face a bad time. I have no interest in seeing my profession serving an elite, even if it were to make me an elite. I believe in hard work, good work, enjoyable work in an open competitive system, with social responsibility. Within government, I see the need for scientific-technical personnel who are responsible to the elected representatives of the people defining a government program that is responsive to the social welfare.

In the case of governmental scientific or other professional activity, the only one who is responsible to you is the government employee, commonly referred to as a bureaucrat, His career (even if not his job itself) rides on his success or failure in maintaining a good and suitable research program.

If you provide him with a peer review system, you have taken away his responsibility. If the program is poor, he points outside for disclaimer. What can you do in this case? What can you do to the peer reviewers? Call them names? They have no interest or responsibility in maintaining a good efficient useful research program for you. Except in the special case of a few particularly conscientious ones, whose number and influence is drying up ever more quickly, such administrative in-house scientists lose their Government social task oriented interest. Instead they identify more and more with the scientific interests of the outside peer reviewer. They regard those interests as the social interests.

The government employees, your employee, should be free to consult any and all (with care as to conflict of interest and proprietary rights); but the decision must be his with no recourse in the case of failure to the theme that reputable and expert opinion advised him. Consider yourselves - both you and even the president, no matter how much advice you collect, you are all personally responsible for your decisions and the voters so hold you responsible. You can't blame bad decisions on others. The same should apply to your servants in the government.

Peer review doesn't spread the responsibility equitably, it hides it. Similarly all those programs which have tried to give direct aid outside of Government, with monetary freedom outside of Government control and with no effective competition. Whether to industry, to the medical doctor, to the cities - immediately those who receive the aid, figure out ways and means to manipulate their take and to inflate the costs. Do you want to be reminded of the medical costs rise? (N.Y.Times Feb.27, 1977, Health expenditure - 1950--$13 billion; 1955--$18; 1960---$27; 1965---$40; 1970---$73; 1976---$140)

Equitable competition at every level is required. Otherwise you have to go to a command economy, and in that case you have to see that every individual - and that quickly turns out to be those who you favor - gets the share you allot him. I prefer a mild welfare system, where you know what has to be done, you encourage it both cooperatively and competitively, and there are moderate competitive advantages to do well. The problem facing you is to encourage neither monopoly, nor neglect.

The Role for NSF

So with one man's flavor of the turmoil beyond NSF, we can state our main theses. What must NSF do?

1. NSF must develop a national science program. It must represent a perception of our national needs. It must serve the needs of all segments of society. It must be reviewed, perhaps every administration; perhaps every 6 year term, perhaps politicized in phase with administrations, or out-of-phase. Science has always been political - in Aristotle's day, in da Vinci's day, in Newton's day, in post-depression, post-world War II U.S.A., in the USSR during all of its history, now in every European country.

2. NSF must develop a line of connection to the needs of the mission oriented agencies of government so that a careful distinction between its role and their role is had.

3. Consideration of the constituencies will suggest the fantastic scope of the problem. A science foundation must serve defense; agriculture; commerce; health; education; economic agencies; energy; technology; societal organization; materials; government. The trap is for NSF to become too intimate with any of its constituencies. We accept the principle that each constituency will and has to defend its self interests, but then it is up to the Congress to see that NSF does not become a captive of anyone. The issue is just as sensitive as with the FBI, the CIA, and DOD, and perhaps even more pressing for our future.

4. How shall NSF achieve its program? Apparently we have to go over this

issue again. It is not the scientist who is important, but the science. As a liberal believer in the free enterprise system, I am against a socialist system. I am willing to accept either the free market or a welfare system. But there is no real free market system in existence any more. As a small business entrepreneur, I assert that dogmatically. So Government must step in to assure equity. The claimants to developing nationally significant science are Government laboratories, large industrial institutions, small industrial institutions, non profit institutions, large for-profit science-technology companies, small for-profit science-technology companies, large universities, small universities. All of these, if they have a contribution deserve access to such funds. They have to make their claims competitively, or their respective claims have to be established. One should note that many of these groups have mixed or conflicting interests. Thus I could ask why does a large manufacturing company have to compete for science funds; or why does an educational institute have to compete for science funds? I know the answer. The market is there, and funds are available. Therefore the control has to be political. All I ask is that I get my fair share by free access. Else the free enterprise system is not working.

As far as I am concerned, I prefer knowledgeable judges who are relieved from advocacy rather than advocates who have their own self interests to look into. Our society has a habit of ganging them up. As one of my daughters notes - there is no such thing as a free lunch.

5. NSF must develop a balanced basic and applied research program that is essential for national needs. You might wonder whether I stress an applied program. No, I stress a program for national needs (not the RANN program which is another academic give-away).

I stress this now and in the past, in preference to the so-called "free, fundamental, uncommitted scientific research and science education" which is what Bush wanted it to represent.

Let us take a case in point today. In the Forum on Physics and Society of the American Physical Society, there is an announcement of a meeting sponsored largely by academic members and a few large industrial laboratories on Changing Career Opportunities in Physics. As the announcement states, these academics and a few large corporate physicists will tell physicists "Why things are the way they are - the factors governing the choices of students ... These include government funding patterns..." with a "General session on non-academic careers - job content and career paths for physicists in industry and government...specific information on some non-academic careers..."

Are most jobs utilizing the skill of physicists just concerned with government funding for academic jobs to teach physics? Do academic physicists know how physics is used in industry and government?

As I read the announcement, it is amusing. Academic scientists have discovered that their subject may have to be used in some common fashion. Persons like myself have been working our full professional careers in applied physics in government and industry. We have been hired and fired and taken all of the standard career risks of blue collar - white collar - professional people. We have dirtied our hands in reality, and we have fought to keep our intellectual status. At the same time we have advanced our science. Must we forever be exposed to that repeated fanatic notion that only one institution is competent to pass on the message from above? That elite nonsense has to come to an end. There is a line of science - from the discovery of its central dogmas, to the development and fleshing out of that theory, to its application as an applied theory for various fields of phenomena, to its actual specific application to operational mechanisms (social as well as physical), to development of design theories for mechanism, to development of actual operational mechanisms wherein the engineering line of tasks begin.

In general, NSF has a role for steps 1 to 3. Steps 4-6 tend to be the kind of tasks, identified in the Army as 6.1, 6.2 tasks, or as R and D in industry.

If anyone challenges my assertions as pure philosophic generalizations, I would be very glad to sit down and write a national science program in a year 'best efforts' contract, or if no agency can afford it, I would be very glad to write such a program at no cost in a month or two. Just ask. You get what you pay for.

Thank you.

APPENDIX I

In March of 1976, I wrote the following letter to Senator Kennedy:

" Subject: NSF Peer Review

Dear Senator Kennedy:

It has become quite fashionable in academic scientific circles to even write polemics in favor of the Government's use of the peer review system in purely scientific journals (Science 190, 1060, Dec. 12, 1975; American Scientist 63, 624, Nov.-Dec. 1975).[1] Since I have a large amount of experience with R & D and don't share academic enthusiasm for their allegiance to peer review, I thought it appropriate to use the opportunity, when asked by National Science Foundation to act as a reviewer, to examine at least one example of such 'peer' review at close hand.

Thus, I recently spent two days, at NSF invitation, reviewing NSF academic institution proposals that would provide them with funds for meeting specific local needs by specifically designed educational programs. The program (CAUSE) was apparently specifically mandated by Congress to get educational institutions conscious of a mission-oriented need to serve their communities. For a program of about $10 million annual size, involving potential three year grants at the $100,000 level, about 750 proposals were reviewed. A panel of about 500 people were assembled at the cost only of subsistence and travel, i.e., upon request, the people volunteered their time. My group, one of 3, was about 150 people, divided into about 30 working panels of 5, each panel reviewing 18 proposals (20-30 pages) in 2 days.

I was invited as one of a small handful of 'industrial' scientists selected to give their review process some further depth.

I elected to go to test my impressions of NSF reviews, reviewers, the outlook of proposers, and the present state of academic thinking. My competitive vested interest for R and D funds should be recognized. Also my 'objectivity', as good as any academic scientist's, and large amounts of diverse R and D and managerial experience - 35 years in government and industry.

Within that framework, I would like to offer my impressions:

1. NSF conducts a welfare state program for academic institutions and affiliates through a grants program.

2. Not meant pejoratively, it would seem that such a program would be more appropriate:

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[1] We can now add a summary of how the academic outlook appears in Congress. "Does Peer Review Work?", Amer.Sci. 65, 17, Jan-Feb.1977.

(a) If it were administered and controlled in a Department of Education. This way it is an unwarranted tie-in sale. of education and science. While NSF may have thus become an outlet for academic funding, it was not the original intent of NSF legislation, which was to serve national scientific needs.

(b) If this were a socialist or mixed system. Grants without mission-oriented goals is a rather utopian aim. In the end there is no real check and balance system.

(c) If the education were recognized as a public system with public accountability, namely if very specific Department of Education guidelines and controls were exercised just like any large Board of Education (And as the issue is developing at this time in New York and Philadelphia, with oversight control that gets rid of fat in the system, and makes it an effective tool to perform its function. The attached articles do not indicate any such local educational competence. Why anyone would expect a national competence to be better than a local Board is an uncertain question.)

3. The responding institutions (I didn't see 750 proposals, not even 250 proposals, but lunch and other informal conversations among the panels indicated a rather common experience among the 250 proposals) did not seem to understand the Congressional mandate, which was "We'll give you some money, if you'll show you can respond to well defined local needs; if you show how you or others can learn from your successes, if any; and if you show how the program might be cost-effective." Instead, by and large their response was "Give us some money, and we'll develop some course work that we're interested in or think we need." I can only regard this as business as usual, the kind of business that a Board of Higher Education might review as part of an on-going process of educational development. Why NSF?

4. An additional common underlying keynote in many proposals was a desperate urgency of many small schools to want to try to keep their faculty abreast of science and technology. This, in my opinion (unchanged), makes hash of the academic chain of intellectual excellence and their claimed right to lead intellectual innovation. I have little doubt of their devotion to the cause of teaching (in these little schools), but I doubt their innovative ability. They are scientific-technical hacks.

5. This is born out in the quality of personnel that were doing the reviewing. Very few (practically none) would I consider good people for R & D at the cutting edge of science or technology.

6. This brings up the review process. I stated why I was there. I would not go very often without a quid pro quo. Frankly I don't think:

(a) You should ask me to donate highly costly time to such a review process, unless you want to hire me full time, and I am highly competent. I give away 'free' time to my technical societies for the benefit of my profession. These donations make hash of the notion of 'low overhead' costs at academic institutions. They literally avoid the issue of any real cost accounting for productive time of their professional staff as compared to all other academic operations. My experience in R and D, with real cost accounting, indicates overhead rates of 100-300%. Any back-of-the-envelope calculations I make for universities easily equals or exceeds these numbers.

If the question is raised whether citizens should not donate time for societal functions, I agree, but there must always be a quid pro quo. Society must reward or pay for these functions in one way or another.

(b) I clearly perceive conflict of interests. Either that or collusion. In my case I view a conflict of interest. Why should I give away public monies to competitors - unless I am rewarded? Thus, until I am appointed or hired as a judge, I don't want to pass on other people's request for their livelihood. Conversely, I don't want such people with conflicts to pass on mine.

Thus I have taken myself off such reviews - whether for monies, or even for technical article reviews - unless the procedure was open, the beneficiaries approved my presence, and it was part of my life career.

(c) Thus I cannot believe that such large 'no-cost' reviews can be assembled unless there is a quid pro quo. In practically all cases, these reviewers are available because they are beneficiaries of NSF or other grants. That colors their willingness to serve. The Congress may argue that this is good, it assures a common interest, the objective random response that all good juries require, but where is the voir dire? In the end it creates the tight guild-like 'in' group that becomes mercantilism, monopoly, and ultimately cartels. For practical purposes the large prestigeous universities already operate as a cartel. Compete with them and you'll soon find out!

(d) Which brings up one personal complaint. I now see why it is hopeless for an avante garde R and D outfit like my own to seek contracts with those agencies that use or are highly beholden to academic reviewers. The problem can be put in the following nutshell:

(1). The reviewers are not our peers. As indicated, most of them I wouldn't hire for R and D.

(2) Clearly in any academic review of our proposals (NSF, NIH, ARO-Durham, AFOSR minimally) (A) they tend to view our proposals

as a threat to their availability to receive funds; (B) they do not grasp the essence of a contractual relationship, which involves guarantees (e.g., best efforts) to deliver a real result. The nominal language of "best efforts" in R and D contracts is not an open ended invitation. It means that for some unknown problem we will put in our best efforts, and if we fail - or fail too many times - we have lost a client. That project office will simply not accept further proposals from us. A continued successful track record of delivery is our only passkey. "Yes, but what have you done for us lately" remains the outlook that we must always face.

(3) Considering the disparity of our experience, they do not grasp how we can possess the competence to deal with complex interacting systems in what seems to be a global fashion. Being fragmented and devoted to limited research objectives and the teaching of students, they cannot grasp the point of view of interdisciplinary applied science and scientists devoted to problem solving on non-canned problems.

(e) They make financial judgments on costs that are neither within their competence nor their business to judge.

There is no way that I can take their peer review system seriously. It is designed for them to judge themselves in a specific limited context.

7. Besides the fact that we operate at different tempos - clearly evident even in the case of the review process (as my panel members can attest - they think with leisure and at student pace. We deal at an industrial mission oriented pace.). I raise the question of competitive objectivity. To run an honest business, you know the lines of ethical practice and performance. You know what your competition thinks and what lines you should not cross. You are constantly in an 'adversary' position like lawyers. On the other hand, if 'promoted' to judgeship, e.g., if you consult, you know how to become more objective and perform the tasks by which the 'law' written or unwritten governs behavior. You know you cannot write the law, execute it, act as judge <u>and</u> jury, and police it. These distinctions are highly rudimentary among academics.

8. Another weakness. It is pathetic to realize that the most common problem facing academia is a loss in competence to do the educational job. (See attached New York Times articles - which I asked my panel about and which they confirmed.) Their major problem is remedial education - both of students and faculty. Yet the continuing claim is "a search for quality education", even though the basics of educational competence is lacking.

One basic trouble is that some few very voluble and personable academics have high visibility and the paid-for sales force to 'sell' academia to the public, both executive and legislative. They leave a false impression of the average range of academia.

9. How do we get the technical job done in this country? (And it is slipping - see attached article.) From 35 years of R and D, I have very specific ideas. This is not the time to discuss them in detail. Suffice it to say I believe government should do its needed applied research in-house, industry also, academia should teach with some small (10%) augmentation for so-called basic research, and that the scientific-technical community should be collaborative, united, and modestly competitive.

Perhaps I have only reconfirmed my own prejudices, or my own experience, and also written a polemic; it is my belief that I make such judgments from a broader base of experience and knowledge of history."

The N.Y. Times, March 7, 1976, first news section, p.1, reports on "Rise in Remedial Work Taxing Colleges", in an article by A. Maeroff. "Plagued by increasing numbers of students who are unable to write coherent sentences or handle simple arithmetic, more and more colleges are finding they have to offer remedial work in such basic skills. Few institutions of higher education, including some of the most prestigious, have been able to escape the problem..." Ohio State, Johns Hopkins, Case Western Reserve, Columbia, City College of N.Y. are a number of examples discussed.

The N.Y. Times, March 14, 1976, first news section, p.1, reports on "U.S. Science Lead is Found Eroding" in an article by V. McElheny. It outlines the findings of a National Science Board study that indicates that a number of nations have improved inventiveness, support for science, and worker productivity faster than the U.S.A., and that our scientific-technological lead has been eroding in the past 15 years.

APPENDIX 2

As a member of the NSF Industrial Panel on Science and Technology, I wrote the following comments for their NSB Report.

May 29, 1975.

" Subject: Comments for Committee on 8th NSB Report

Dear Mr. Thieme:

I am answering your May 23rd letter on the assumption that you really are interested in value-free scientific - technical commentary rather than one that is politic. Having just completed a first round of studies on scientific social analysis and forecast, including a three generation prediction for the U.S.A., I will address myself to the question of "circumstances in the... [social] environment which will influence the [future] productivity of working scientists and engineers".

Thus regarding critical issues facing fundamental research in the near (next generation) future:

1. Problems I anticipate as an industrial research director. A convergence, within the social system, of the first early appearance of rate limiting processes that interfere with the orderly operation of our social system. Since these rate governing processes do not appear at infinitely sharp thresholds, but are spread over a few generations, it would be foolish to attempt to pinpoint precise dates. Suffice it to say that the appearance of a first and a second round wave of such processes are on the horizon. These include materials shortages in both absolute terms and in the costs of increasing the flow of these materials and substitutes; costs in overall wealth for defense; costs of maintaining inadequately producing urban concentrations.

The resolution or solution for these problems involve a very large burden of technical planning, but one that does not encroach too extensively on the political process. I am in process of outlining such planning. The very real problem is that there are fantastic pressures to end up with inadequate or no planning, or with highly regimented and doctrinaire planning (both left and right wing ideologies), with only a very limited possibility to steer in between. The computer revolution, as applied to some of the very advanced corporations, has shown that a large degree of planning control is possible which still leaves a large degree of freedom for free policy decisions. Clearly, it is simply the situation that a properly regulated and controlled system can operate quite freely at some time but has to operate quite closely controlled at others. Thus the basic problem I see is whether there is a real hard science for the control of such systems. We have been developing such a science under Government agency sponsorship. We would be very pleased to present our notions to any audience NSF cares to designate.

2. <u>Critical issues that decrease effectiveness (of performing or achieving necessary research)</u>. The critical issues that decrease our future technical effectiveness have already taken place. They are, post-1945 World War II, Korea-1950, space program-1960, Viet Nam-1965. One or two of the latter three were too many calls for national unity of purpose. The fact that the next crisis stage is upon us is crowding too many calls for national goal-directed effort on a society about one generation before it can take it again.

The technical issues to be resolved are not difficult. They involve the same amount of organization as for any 'war'. That includes, perhaps, sufficient time (e.g., 2-4 years) to mobilize peoples' attitudes. Then the problem of about a 1-1 1/2 generation program period (not 1985) to develop energy independence, substitute material conversion, development of a food and population policy, development of a total new long range policy for defense, and development of a long range urban-suburban-farm land use policy could readily and easily be accomplished.

What is of major concern to me is the very real threat of left or right wing take-over (not in a decade, but in two or three) if we don't get on with the required technically-led 'war'. And there is no way that technical people can lead the way. At most they can do what I am attempting to do, call the issue to the attention of a leadership in the hopes they might listen."

APPENDIX 3

Advanced Technological Planning for
Interdisciplinary Research

(Exerpted from our 1965 report to the
Army Research Office)

" What is the distinction between
science and education?

For a number of reasons, the problems of science and education have become co-mingled since World War II to the extent that there exists a devisive issue that can be corrosive of the accomplishments of science. This study is concerned with science and not education, so that the only reason for bringing the issues of this great debate forth is because of its significance for the future of American science.

Two extreme views of the debate may be expressed as follows:

1. A complex technological society required specific preparatory education for that society. In particular a well qualified elite must be so prepared. The selection function and training can best be done by the university as a repository of the best practices of mankind. World War II created three problems: one, a need for science to pursue the war effort -- for this the universities jumped in and admirably showed their ability to do both pure and applied science; two, conditions for a population explosion, making adolescent education two decades later a most pressing problem; and three, the creation of a very large technological revolution, requiring its vigorous post-war exploitation. Post-World War II problems, our relations with potential enemies, as the east versus the west, has left us with a prime need for advancing an applied science and technology. The university is the only well qualified source to meet the challenge of needed science, both pure and applied. However, science cannot be directed. Thus, the Government should support science at universities

the only source of self-directed science, to secure the future needs of the nation, without hampering the freedom of the university. All research and development involving science, should be conducted at universities or their institutes, by undefined private agreements with industry, but with the Government keeping hands off.

2. The increasing complexity of society has required upgrading of education for society. In particular, a well qualified citizenry must be generally prepared. The selection rules and goals and directions must be defined by society for its own ends. The university has the responsibility for developing the best means of carrying out training for these ends of society. As an independent problem, American science, born under the weight of an inferiority complex by being compared with European science, and living under a social tradition of engineering ingenuity, was an infant in the 19th century, began to root at the turn of the century, and began to flower in the 1930's. A small but reasonable role had come into existence by that time for Government, industrial and university science. If anything, each group had a very narrowly defined but properly centered role in its social charge. World War II and a dependence on intellectual elites provided the university with an unparalleled opportunity to taste of the role of intensively directed science. However, both industrial and Governmental science were also intensively involved. Post-World War II posed five problems: an unprecedented demand for education, first from the GI generation; and later from their progeny; a deepening financial crisis in the schools, colleges, and universities since the thirties in which ultimately Federal funds became particularly attractive at the upper education levels; the post-war need to exploit the new technology of World War II; the continuing crisis with a need to find useful social tasks for a growing youthful population. These have led to an unwarranted mixing of the problems of science and education, in which an increasing scope of Federal funds goes both into the schools and industry to use science as a training device to keep a large market of technically trained young people available, to keep the academic mind occupied with the problems of the industrial and military technology, to create ideas for the future, and to prepare a youth for a new social-technological outlook.

The more valid alternate to these above, is that Government needed science should be controlled by Government, substantially in its own laboratories, with public accountability -- this is simply a confirmation of the purpose and content of Government science since the turn of the century; industrial science should be done in industrial laboratories, or may be purchased privately from scientific service organizations -- this also continues the content of industrial science that had its beginning at the turn of the century (or earlier in Europe). If it is deemed in the public welfare, as a matter of publicly debated policy, to encourage both scientific research and development, this may be done by various subsidies, such as favorable tax treatment, etc. Universities should teach and prepare students for the needs of Government and industry, but most important for society, in accordance with the publicly selected aims of society. Free research directed toward 'pure' research ends may be done by university scholars, if they consider this fundamental to their survival. Mild Government subsidy (with the emphasis on mild, such as 10 - 20% of salary) is possible, if deemed in the public interest as a result of public debate. The education of the young and keeping them involved must be subject to a great debate, and is likely part of the problem of design for a great society. It is presumptuous to propose any judgment as final, but history, including recent history, suggests that youth can be inspired with the great tasks, the 'dirty' tasks that society will seldom afford, if the time scale is finite. Thus a Peace Corps for two years, the W.P.A. for a few years is attractive, whereas the Virgin Lands in Siberia for a life-time is not. If the motivation and idealization is great, then youth can serve and be served, else not. (This point is well-taken for an Army, which has been often confronted with the task of being a dumping place for youth, regardless of their fitness for Army ends and tasks). This is a much better directed end than to mix up the task needs of science and education.

It is somewhat an illusion that the universities are the repository of expert knowledge. They are not. They are the sources of rudimentary training in various subjects. (Obviously they do not want to be involved, in specific detail else why would they withdraw from the public market place where the applied problem is pursued with considerable involvement?) They do not represent, as a broad rule, the main serious applied research workers in their fields. A rebuttal to this would have to indicate that a serious research worker could spend only half his time at research and other half teaching. Alternately the claim would have to be made that the researcher actually spends full time at research, in which case the question would have to be asked, 'Is the activity performed with a full time staff of graded professional levels?' There are two possible answers; one that science only needs the inventive genius of the individual, so that a staff is not necessary; or the other, that the individual has the staff, in which case the question is raised, 'What is the activity doing at the university?' These latter two points require clarification.

Science is a discipline that climbs on the backs and through the minds of many men. Because of the fact that it involves a large number of non-physical steps (namely, thought and logic) it is often identified as a companion piece to witchcraft. It is not. It is a profession, a craft, even a trade, in its most skilled form like a master builder, or in less skilled form as the individual carpenter, bricklayer, plumber, mason that builds parts of houses. Like a shoemaker or any other artisan, there are no thirty day wonders. Brilliant flashes can add pieces, but they do not make the whole. The daring of youth also has no particular effectiveness in advancing the science. It moves like a heavy sled with lots of dry friction. It advances imperceptably bit by bit due to many people looking at the sled and pushing. Occasionally someone more skillful than another figures out a way to get a particularly effective piece of goose grease under the runners, but historically it does not pay to bet on his race, color, religion or age, just that he has devoted intensive thought and training (whether of self or by others is only a matter of efficiency) to the problem. The individual genius idea is thus a convenient myth. (This has nothing to do with the question of how to build up a talented individual within a group). Organizing for science is thus framed as an activity in which one must build a group most suited to the task.

Under these conditions, what then is the objection to building scientific groups at universities? It is the following: Science, as are other activities in a free economy, is a matter of free choice made by individuals. It is reputed to be a social good, as opposed to a social evil, so it does not have to be legislated against. Economics help determine the attractiveness of the field to individuals. Supply and demand gradually shake down a unit price for the cost of research and the researcher. Not having the tight guild structure of doctors, or lawyers, or the trade union structure of the trades, the going price is somewhat low, but not impossibly so -- a median salary in the $8,000 - $9,000 range. The total price, including overhead, runs about $22,000. per man year (down to $18,000. at more economical levels, and up to $25,000. at less economical levels). If the private university runs a research institute, giving the same kind of support that is implied in the overhead figures, there is only the quarrel with the direction of the competition not the competition itself. However, when the university cuts the price, not by offering full time people, but graduate students, part time retainers, etc., this wrecks the base for building up a sound American science. It cannot become an attractive field to enter. The merit of this point of view can only be understood as a long run proposition. To buy research at cut prices from universities not supplying full time researchers at going rates is to hurt the research picture of the U.S.A. in the long run. Its immediate effect is to encourage a greater number of young people by subsidy into a field that cannot realistically support their efforts economically, and therefore will result in a future swing away from science."

Written testimony - A. S. Iberall - continued

The history I have reported on brings me up to what I have learned since 1950:

1. At the NBS where I had worked, we had to compete vigorously for scientific-technical funds. There were few guaranteed resources. Thus, within my former section, we were much too busy seeking out funds and doing the science needed to have too much idle review time. That proved foolish for NBS security.

2. When I went into small business R and D and thought that I only had to do a job cheaper, faster, better than my competition, that proved to be near sighted. As time went on, my competition - with essentially all the classical monopolistic devices - have frozen us out. Our competition in R and D are in the large universities, the large aerospace corporations, the not-for-profits, and the large for-profits. It is not their size, their technical know-how, nor even their sales force, which bothers us. It is the suspension of what had once been normal modes of competition. Their preferred instrumentality role - via peer reviews, study commissions, panels, and councils; their high mobility in which no conflict of interest is seen - is what defeats us. We are back to Kilgore's original interests.

3. When we became involved in consulting R and D-for-profit, we could sense that control of big science was open until the mid-1950's. Then academia moved into the role. NSF, NIH, DOD provided them with both seed money and opportunity for bootstrapping operations to large amounts - buildings, facilities, institutes and the like. The NAS and the NAE are loaded by recipients of such monies. Similarly big development was taken over by large

aerospace corporations. Thus we were told in the mid-60's by our industrial clients. "We don't need you. We can get academic R and D cheaper, with greater prestige, and we get to keep the slave labor that has already been especially trained for us."

4. Meanwhile we have grown in technical competence. (You either grow or wither.) We could almost single handedly grasp most of the scientific problems of concern to society. Years of attention miss very few. There aren't that many. Parenthetically we make no claim that we could embrace all the engineering problems. There are simply too many. Thus in the late 50's. we felt competent to present a "Science for Society" proposal to NSF. We thought that NSF was open for themes of national significance, and by that time, in our own research directing experience, we were ready to begin scientific generalizations and attacks on large scale scientific problems. But the NSF staff did not see how a small R and D firm could do a "science for society" piece. That was the first time that I really learned that the originating efforts more than a decade earlier had been diverted. NSF was not in business to do science of national concern, but to support a particular frame of scientists.

That particular story doesn't have a completely unhappy ending. It took time, in fact 5-7 years, but we finally sold the project to DOD in the Army. Our report was entitled, "Advanced Technological Planning for Interdisciplinary Research". Our project officer, the Deputy (civilian) Director of Army Research clearly and often indicated that the place of that report was as a companion piece to the Army Research Plan. We regarded it and still regard it, as a first such staff document that should be reviewed and rewritten every 5- 10 years. We recommend that thought to any government official. But there was no room for such studies at NSF.

5. In subsequent years, each number of years after we forgot the discomfort of approaching NSF, we have come back to them. Why? Because we continue to develop major material of significance to national interests. We know that other narrower mission-oriented atencies cannot and will not take on the tasks we propose, and NSF is the plausible place. In each case our proposal was not to do something that had been done before, but to open a new avenue of attack on major fields, that neither academic nor large commercial nor nonprofit organizations had thought of or developed. Our most common review critique was that as small business R and D we were not competent to do the task.

6. Now the fact is we were ready in the mid 40's, the mid 50's, the mid 60's, and the mid 70's, each decade with increasing depth, to write the outline of a national science program and to undertake many of its pieces. The first task of writing is inexpensive, and can be done quickly. The second is a much larger task, and we are not volunteering for it. But there are very specific pieces that we know we are uniquely competent to do. And from a national point of view at least one major task that we want to do is highly important. It is to produce a general science of complex systems - common to nature, life, and society - and to flesh out as many pieces as we can to guide scientists, engineers, administrators, executives, politicians, in the management of society's interests and needs. It has been an obvious task for NSF. We cannot sell this at NSF. <u>That</u> science, or more particularly <u>interdisciplinary science</u>, really has relevance to society's problems but is still not a saleable commodity. It still awaits a <u>Prince</u>.

I have only burdened you with this personal historic view because my interests and development mirror in a small way what <u>have</u> to be the national interests, and in particular in the field of science, NSF's interests. It is my basic assertion that NSF has diverted the national concern and need for science, in its broad perspectives to serve a narrow constituency of academic institutions, and problems.

Summary - The Problem Facing You

In summary the issues we faced in the 30's, and the 40's, and in the 70's have the same roots.

There are no endless frontiers - there are only needs and missed opportunities to get on with the job of making it possible for all to live and contribute creatively to the common and individual welfare - in expanding times or in bad times.

Again we face a bad time. Science ought to be useful. I have no interest in seeing my profession serving an elite. I believe in hard work in an open competitive system, with social responsibility. If there is to be social control of science in an NSF program within government, I see the need for scientific-technical personnel who are responsible to the elected representatives of the people defining a government program that is responsive to the social welfare.

In the case of governmental scientific or other professional activity, the only one who is responsible to you is the government employee. His career rides on his success or failure in maintaining both a good and suitable re= search program.

If you provide him with a peer review system, you have taken away his responsibility. But there remains no control of the peer reviewers. They have no interest or responsibility in maintaining a good efficient useful research program for you. Except in the case of few particularly conscious careerists. whose number and influence is drying up ever more quickly, the administrative in-house scientists lose their Government social task-oriented interest. Instead they identify more and more with the scientific interests of the outside peer reviewer. They regard those interests as <u>the</u> social interests.

The government employee should be free to consult any and all (with care as to conflict of interest and proprietary rights); but the decision must be his with no recourse, in the case of failure, to the theme that reputable opinion advised him. Consider yourselves and even the President. No matter how much advice you collect, you are all personally responsible for your decisions, and the voters so hold you responsible. You can't blame bad decisions on others. The same should apply to your servants in the government.

So peer review doesn't spread the responsibility equitably, it hides it.

Equitable competition at every level is required. Otherwise you have to go to a command economy, and in that case you have to see that every individual gets a share. I prefer a mild welfare system, where you know what has to be done, you encourage it both cooperatively and competitively, and there are moderate competitive advantages to do well. The problem facing you is to encourage neither monopoly, nor neglect.

The Role for NSF

So with one man's flavor of the turmoil beyond NSF, we can state our main theses. What must NSF do?

1. NSF must develop a national science program. It must represent a perception of our national needs. It must serve the needs of all segments of society. It must be reviewed, perhaps every administration; perhaps every 6 year term, perhaps politicized in phase with administrations, or out-of-phase. Science has always been political - in Aristotle's, da Vinci's or Newton's day, in post-depression, post World War II U.S.A.; in the USSR during all of its history; now in every European country.

2. NSF must develop a line of connection to the needs of the mission oriented agencies of government so that a careful distinction betwen its role and their role is drawn.

3. Consideration of the constituencies will suggest the formidable scope of the problem. A science foundation must serve defense; agriculture; commerce; health; education; economic agencies; energy; technology; societal organization; materials; government. The trap is for NSF to become too intimate with any of its constituencies. We accept the principle that each constituency will and has to defend its self interests, but then it is up to the Congress to see that NSF does not become a captive of anyone. The issue is just as sensitive as with the FBI, the CIA, and DOD, and perhaps even more pressing for our future.

4. How shall NSF achieve its program? We stress: It is not the scientist who is important, but the science. As a liberal believer in the free enterprise system, I am against a socialist system. I am willing to

accept either the free market or a welfare system. But there is no real free market system in existence any more. As a small business entrepreneur, I assert that dogmatically. So Government must step in to assure equity. The claimants to developing nationally significant science are Government laboratories, large and small industrial institutions, nonprofit institutions, large and small for-profit science-technology companies, large and small universities. All of these, if they have a contribution, deserve access to such funds. They have to make their claims competitively, or their respective claims have to be established. One should note that many of this groups have mixed or conflicting interests. Therefore the control has to be political, if not free economic. All I ask is that I get my fair share by free access.

And as far as I am concerned, I prefer knowledgeable judges who are relieved from advocacy rather than advocates who have their own self interests to look into.

5. NSF must develop a balanced basic and applied research program that is essential for national needs. You might wonder whether I stress an applied program. No, I stress a program for national needs. I stress this now and in the past, in preference to the so-called "free, fundamental, uncommitted scientific research and science education" which is what Bush wanted it to represent.

Let us take a case in point today. In the Forum on Physics and Society of the American Physical Society, there is an announcement of a meeting sponsored largely by academic members and a few large industrial laboratories on Changing Career Opportunities in Physics. As the announcement states, these academics and a few large corporate physicists will tell physicists "Why things are the way they are - the factors governing the choices of students ... These include government funding patterns..." with a "General session of non-academic careers - job content and career paths for physicists in industry and government...specific information on some non-academic careers..."

Are most jobs utilizing the skill of physicists just concerned with government funding for academic jobs to teach physics? Do academic physicists know how physics is used in industry and government?

As I read the announcement, it is amusing. Academic scientists have discovered that their subject may have to be used in some common fashion. Persons like myself have been working our full professional careers in applied physics in government and industry. We have been hired and fired and taken all of the standard career risks of blue collar - white collar - professional people. We have dirtied our hands in reality, and we have fought to keep our intellectual status. At the same time we have advanced our science. Must we forcver be exposed to that repeated elite nonsense that only one institution is competent to pass on the message from above?

There is a line of science - from the discovery of its central dogmas, to the development and fleshing out of that theory, to its application as an applied theory for various fields of phenomena, to its actual specific application to operational mechanisms (social as well as physical) to the development of design theories for mechanism, to development of actual operational mechanisms wherein the engineering line of tasks begin.

In general, NSF has a role for the first 3 steps. Steps 4 - 6 tend to be the kind of tasks, identified in the Army as 6.1, 6.2 tasks, or as R and D in industry.

If no one else will take up the challenge, I would be very glad to sit down and write a national science program in a year 'best efforts' contract, or if no agency can afford it, I would be very glad to write a quick version of such a program at no cost in a month or two. You need only ask.

Thank you.

With regard to some of Senator Kennedy's questions:

Q. Why is it so difficult to get people interested in science?

A. Because it is a difficult subject. As the sum of rational thought about complex phenomena, its story is complex. It is the same reason that people can't play Beethoven sonatas.

Q. Why does R and D industry need NSF funds?

A. As an industry they don't. There are two types of entrepeneurs (beyond business, the same division holds for all other professions). Those who have one singular idea and intend to milk it commercially. There are those who intend to make a living in a particular service - professional area. I have no sympathy (see my written remarks on security) for Governmental support of the former, although the Senator may have. My view is that in free enterprise, you take risks. Other views are to support it if it makes jobs. On the other hand, if Congress wants to develop a National Development Corporation with some such national goal in mind, fine, that is Congress' business. But return to NSF. What should be its charge? The science of complex interactions, for national needs. For that goal, there is a portion of the R and D industry who can be and easily are major contributors. That activity requires NSF support. NSF and other agencies (e.g., NIH) as well as more common DOD source should be open to fund all those who can contribute.

Q. Is industry interested in basic research?

A. No, neither industry nor your academic institutions are interested in basic research. Industry is 'thing' oriented (product, sales, profit, the game of competition). In 1977, they still barely tolerate engineering. Science is a complete mystery to industry. The small handful of show piece companies have been used all this century to 'prove' scientific interest. To indicate why academia is not interested in basic research is ancillary to the question, so I won't expand. Academic institutions are interested in the maintenance of a big, rich, or important establishment.

Q. What is the problem with regard to nondirect labor costs (asked both to an academic and an industrial panelist)?

A. Organizations have overhead. Whether in Government, academia, or industry, the real overhead figures are comparable. Outside of quantity discounts, and tax exclusions, the same 'free' market prices govern. So it is only a question of 'business' bookkeeping. Academia, when they started seeking Government grant funds, did not have to exhibit overhead. The grants were gravy. So they could make a virtue of it - 10-20% was 'all' they needed. As the drug habit grew, namely the dependence on Government funds increased (remember students and states still pay), they dragged their required overhead rates on grants up to 50%. Now with the crunch, they are trying to drive for standard overhead rates. Regardless of students and other revenue sources, they would like Government to pay all their overhead. Overhead is practically a standard number. It is in the 100-300% range. There are 'biggies' who can justify 500%, but then all these numbers become matters of creative accounting. The matter of a fee for profit - I believe its deserved, and to hell with justification about the cost of capital, etc. - is a red herring. Suppose we put 6% out explicitly or not in a contract. What is made as 'profit' (i.e., from whence capital assets will grow) is only a matter again of creative accounting. As Dr. Barger pointed out, if a company (I'll add university) is in the R and D business - it has to charge all those costs relevant to its consultation business. It has no other pockets to draw from. What Barger did not say and academia does not say, is that they don't mind charging overhead even when their capital holdings grow because their client is paying for it. I always look at how much BB and N's (or A. D. Little, or Battelle, or G.E.) total assets have grown as a result of Government contracts. Similarly I look at how MIT's (or NYU or U.Pa.) assets have grown by Government grants. That's the only way I know what overhead expenses and profits existed and were met.

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Upper Darby, Penna. 19082

215: HI 9-2333
JA 8-6093

March 11, 1977

Ms. Ann Strauss
Senator Edward Kennedy's Office
Senate Office Building
Washington, D.C. 20510

Dear Ms. Strauss:

Unfortunately I did not receive the letter of invitation and a copy of an NSF document, explaining more in detail that what was wanted in my testimony might include comments on that NSF report, "Research in Industry: Roles of the Government and the National Science Foundation", until after the hearings (March 4). The general written testimony I offered properly tends to introduce the specific comments on that report that I am appending here.

Sincerely yours,

Arthur S. Iberall

Arthur S. Iberall

ASI:IG
Encls.

Comments: A Report on Research in Industry
Roles of the Government
and the
National Science Foundation

A. S. Iberall

p.1, P. 1. It is unfortunate that the appraisal of the impact of research upon industrial development has generally been implemented by academic institutions, rather than including others who have been occupied with such appraisal.

p.1, P. 3. We would therefore urge, similar to the point above, that support for input to that study be provided for the nonacademic community who have the background.

p.1, P. 4. As a member of an NSF Industrial Panel, I do not feel that our committee was particularly consulted on these issues; I was never solicited for comments on the Task Force report. I was solicited for the NSB Report which asked some specific narrower questions.

p.2, P. 2. One notes that the concern is with the contributions of industrial research to national purposes. There is a basic twist here that requires exposure. Note p.1, P.1, NSF has long been concerned with the scientific activities of industry. My experience suggests that their interest has only been 'academic', 'intellectual'. One wonders why they should be concerned with the contributions of industrial research to national purpose rather than their own contribution, or their contribution to industrial development. Again are these always to be only academic studies with no real impact on societal goals? It would be useless to waltz around and name all the possible study ends.

The ones I perceive of significance:
What can science do for national purposes?
What can industry do for national purposes?
What can government do for industry?
What should government do for science?
What can science do for industry?
What can industry do for science?

It will be interesting to see what the report opts for.

p.2, P. 3. Immediately it is clear that lip service to motherhood was elected. Does the finding mean that NSF's primary mission is to develop the basic sciences - pure physics, pure chemistry, pure biology, pure geology, pure mathematics, pure psychology, pure sociology, pure anthropology, pure economics, pure political science?

The inappropriateness of the task for government is so glaring that I will spell it out.

The content of 'pure' disciplines is taught at schools. The schools in fact are strongly discipline organized and insist on that structure. Where do the teachers learn that material? In schools. If they want to learn more, they either develop it themselves, or go out in some outer world.

Is there an industry that develops new 'pure' disciplines?
If one considers it to be the education industry, then they sell it to the students.
But we have a theory of government that education is a commodity to be supplied by the state, or at least up to a certain level. And in fact there is a private sector that believes they can supply education at 'extra' cost because it is 'superior' education. Fine. But then why should the taxpayer pay for it, unless he is automatically entitled equally to share it? So there is a major component of education, namely what portion of education should be paid for by government, that belongs to Boards or Departments of Education, just as in the same way you can decide how much transportation is to be paid for by government. That cleans up a part of the legislative process. It takes questions of whether remedial education, education in two year colleges, upgrading the teaching of teachers out of NSF, where it does <u>not</u> belong. I am not against science education and the needs of science educators. I am against their useless competition with me in the development of science needed by government which is part of my consulting industry.

If it is argued that the development of disciplinary science - basic 'pure', applied, interdisciplinary or not - is an essential need recognized by government - for example it may be recognized so for defense, education, the general welfare, health, the viability of our industrial and commercial institutions - then I can see it being performed within government under the following institutional arrangements. Government can create institutions of science. There is long European tradition for that. Government can solicit, by contract, the development of such science. It can do so by transferred funds from other agencies, it can do so by contract with corporations who, part time or in whole, devote themselves to such tasks. It can do so, on contract with teaching institutions. But clearly, in every case, one must understand that there is no conflict of interest, monopoly, no one gets paid twice, etc. You cannot highly subsidize one group, give them special status, and not expect in time to hear citizen complaint.

If you believe basic Science Institutes are in the national good, fine. A government institute in radio astronomy is fair; in cosmology is fair; in weather is fair. But when you contract privately for a Jet Propulsion Lab, a Rand Corporation, a MITRE, an NCAR, you don't know what it looks like outside. Suddenly you are squeezed out of competition in weather research, in transportation research, in water or military research, in space research. If you think their existence outweighs the loss of competition, you should open public discussion so you can find out what happens.

I cannot understand a foundation that gives away funds by obtaining the judgment and approval of those it gives funds to. In industry, we would immediately recognize it as conflict of interest. and we would understand that it very quickly leads to cronyism. Do you want to create Seven Sisters in every field?

So I will illustrate what is fair, and what is not fair.

A government institution that develops such science is fair.

A knowledgeable government institution that arranges contract research is fair.

A transfer fund contract to the Bureau of Standards to develop a fundamental handbook on measurement is fair. If you want NBS to develop a fundamental handbook on instrumentation, you have to hold legislative hearings. Is the benefit to the nation, say, to promote commerce and industry greater if the function is performed in the government, or is it of greater value to let the instrument and perhaps publishing and perhaps academic industry provide such materials on instrumentation competitively?

A contract award to the small R and D firm to develop the outline of a national research program for national needs for an NSF is fair, if it was awarded as a result of open competition and judged by competent NSF in-house judges. If some problems, like these, are open ended in the sense that there may not be one unique answer, it is fair to award a number of parallel contracts, or it is fair to award a number of contracts - as a priori set asides - from different sectors. Science is <u>not</u> like the development and production sector. It can have more than one answer. And industry - among others - knows that a number of 'design' studies, in early stages of decision making are not expensive.

A contract award to a physicist academic consultant to develop quantum electrodynamics as a competition or negotiated contract among a small handful of qualified academic people is fair. Specialized fields may only have a limited number of qualified organizations.

A contract with some 'not-for-profit' institution to develop a basic field of semiconductors, semiconductor materials, semiconductor properties requires hearings. It is not the question of whether the organization is competent or whether or not the contract was achieved, but whether the public interest is better served by the competitive edge it gives the institution, rather than leaving the field to competitive exploitation.

And obviously the same question is even more ticklish in the case of a profit corporation.

Now clearly there is a big push today to point out that the U.S.A. may be losing its competitive advantage. This requires very careful public inquiry. I attend a yearly conference of Administrators of Research - Industry, Government. and Academic. One may surmise that the subject of the energy crisis and what to do for research in the area must have come up last year. It did. When the debate was finally well on the table, it dawned on me what the basic question was. "In solving our national problems", I asked, "The basic question facing you is cooperation, competition, or chaos. Which do you prefer?" I regret that by the end of the week, among the Research Administrators - supposedly highly rational comprehending people - the answer was clear - chaos! It is not just that each self interest governed, but there was no willingness to lay out the big problem and see how the pieces could fit together. Perhaps the President is right in going to the people for answers. I am not sanguine.

The point here is that the basic science for national needs is needed. It is <u>not</u> the pure disciplinary science. Thus NSF and its panels continue indefinitely to mix up the problem and to present those outside of science, e.g., Congress, the public, as a mixed tie-in sale.

p.2, P.4. I cannot accept the first sentence. There is an arrogance in it that is riding for a fall. I absolutely agree with the second sentence. With regard to the third sentence (mission-oriented support by both government and industry), while I agree, that requires acceptance of the division, case by case, in public hearings. I accept the fourth and fifth sentence. I do not accept the sixth (multidirectional knowledge largely academic). People like myself can, do, and will compete in these areas, whether we are in Government, industry, or academia. I agree with the seventh sentence, although I will point out that past a certain level of education, the remaining training is better done by on-the-job apprenticeship. I am not discussing the blacksmith art. I am discussing basic research, applied research, and development. It would make hash of what I have learned in 30 years of directing research to accept the contrary. I don't understand the eighth sentence. And I certainly do not agree with the ninth (and last) sentence.

p.3, P.1 (following) I accept sentence one. Sentence two is not an apt summary why industry doesn't support basic science. Industry hardly understands or trusts engineering. Any effort to sell engineering R and D to an extended group of industrial companies quickly demonstrates that. Thus science is even more a mystic art. Industry does not think in terms of long range plans. It is reactive to the present or what it knows of the past. It has no basis or experience for connecting up any long chained intellectual argument. I n fact it sees no way that such long chained arguments have any application.

Sentence three thus becomes a nonsequitor: 'as a result', perhaps in certain people's minds, NSF becomes a principal vehicle. But even as a factual statement, in its own right, this is not correct.

Some may wish to make it a principal vehicle. But actually it is society who 'tolerates' research and science in a great many cubby holes that makes its development possible. It permits people to pursue science - in academic settings, in Government laboratories, in industrial laboratories, in large and small industrial laboratories, in profit and nonprofit institutions. The sentence smacks of the effort to establish one religion and one church. The notion will not wash.

p.3, P.2. I accept the first sentence, although it is dragged in by the tail. As my written testimony suggested there is a line from the development of content of the pure scientific disciplines to applied science to science for mission oriented agencies on to engineering. It is a dual responsibility of professionals on both sides to work out connections. Thus, per the second sentence, managements (of American science, in its parts) have to see toward some measure of division of responsibility and effort.

p.3, P.3. I have no objection to the underlying of the first sentence, but -. Once upon a time there was a famous inquiry into the national needs in education, e.g., education in a democratic society. We need such an inquiry today, as science in the service of society. Or as the Humphrey-Hawkins bill is trying to point out, we need an inquiry into what role industry is to play to maintain our future national health, and then, whether science and technology has any importance for that role. (I of course believe it does.) But without some such base of comprehension, the call for strengthening industrial R and D (pointed at Congress) is just one additional boondoggle. I of course am in favor of it, but that would only mean that it serves my self-interest. Industry needs R and D for its survival. They don't believe that. That's why in my written testimony I included a small piece, based on an NSF study, that shows we are slipping. To say to the Federal Government, "Gimme, Gimme, Gimme", doesn't solve their problem. So the second sentence means nothing.

Clearly we have the background and competence to comment on the report sentence by sentence, but no one will read it. So we will now jump to comments by paragraphs.

p.3, last P. Diminished R and D funding by industry. We would ask consultants who are advising on the subject to report with a broader background and understanding of the issue. The issue begins with Bush, "The Endless Frontier". and two protagonist views. Our view - American science has to come out of its shell, with its inferiority complex. It must become a common tool - industrial R and D for industry; Government R and D for government; basic desciplinary science and teaching for universities. In industry about 2% of sales should go into applied research. Bush view - science is for a university elite in furtherence of their goals. Our view was lost. The universities have certainly taken over science. But industry has had no (little) interest under those rules. So 30 years, 1½ generations later. there is wonder that industry has diminished its funding. Cassandra warnings may be disliked, but those of us who have been making them for those intervening decades don't enjoy when we are finally swept away.

p.4, P.1. No simple specific actions on 'incentives' are going to affect industry's views. They may serve some special self-interests.

p.4, Sec.B. The entire implication in this section is that support of pure disciplinary studies is the role of NSF. I challenge this. Thus one can't make sense of the situation when an employee of company X (any number of examples can be furnished) can get an NSF grant because the company doesn't want to pay for his services, but wants to keep him and suggests that in the view of his 'pure' interests that he should get NSF to pick up the tab, as happens under the current rules. By NSF rules they regard the situation the same whether from academia or industry, but that only a few rare individuals could qualify from industry. I find in both cases a legislatively unacceptable situation. Again, what does the support of 'pure' physics have to do with government?

With regard to communication between university, government, and industry, the comment that an improvement is needed is utterly naive. It exists to the extent that the participants want it. The three avenues of employment have always been open. The technical societies have always been meeting places. Perhaps much like the reimposition of ethnic, racial enclaves after a more open past, some groups forget, apparently academic oriented scientists have forgotten and now want more access to industry, or vice versa. As an individual from industry, I am quite well known among academics in the many technical circles I frequent. Again is this only a device for academia to find better self-serving financial arrangements with industry?

With regard to improved communication between industrial science and Government, the same remark holds. If you want to lobby, lobby. All groups are doing it. Every technical society is doing it. Perhaps as young social action oriented scientists (see my written testimony) we were doing it earlier than most, but please, as in all matters of science, technology, and the public interests, don't discover sex or the wheel again and again.

With regard to small high-technology firms with large R and D commitments and their need for special consideration by the Government, I would make the following comments: It is my area of self-interest, so I have 'biases'. If there were open access to Government and industry funds, as there was, more or less, in the 50's, then I don't need any special consideration. But if you begin to encourage special instrumentalities load up committees and commissions, provide grants and contracts by subsidy and outside of competition, etc., then I need help for one of two reasons. One, I am a depressed industry. As a minority, I join Chicanos, blacks, small cities and need relief. Some want capital; we prefer set asides. Subsidize us as you do many other segments. If there is a useful Department of Agriculture, it would be nice if a Small Business Administration or a Department of Commerce would take a real interest in us.

But second, more important reason is that we are an important national asset. You really would have to get down to detail to understand all of the technical things that we manage to achieve. But at that, there is little special consideration I ask except a free market access to help do scientific-technical things for my society. If the competition is overwhelming, provide us with shelter, e.g., with set asides. I don't think you have to provide us enough to get rich. That depends on the free marketplace.

Thus with regard to the support of development for profit by such small companies, I take a neutral role on their need for Government support of their developments. If the national policy is for direct Government intervention to create wealth, fine, support them. But this again is a mixed role for an NSF. It belongs to Commerce.

When we approach NSF's programs relating to the Governmental framework for industry R and D, Policy Research, RANN, and the like, I find them all narrowly academic tainted. One would like to find some bold scientific strokes that lay forth a science <u>of</u> society, <u>of</u> government, <u>of</u> economics, <u>of</u> international relations. Even if not successful, they would at least stimulate discussion. Instead one finds a large stock of study trivia. Why needs it; who does it serve?

It is not one whit prettier, when this study concludes that "Discussion with .. consultants indicates that a major need of these (small high-technology) firms is for innovation or venture capital for purposes of product development rather than research." I agree that this implies policy consideration outside of NSF. That should be an SBA concern. The concern in this report, and in NSF should be science and research for society.

A REPORT ON RESEARCH IN INDUSTRY: ROLES OF THE GOVERNMENT AND THE NATIONAL SCIENCE FOUNDATION

I. BACKGROUND

p.1, P.1

The National Science Foundation has long been concerned with the scientific activities of U.S. industry and has frequently addressed the relationship of industry to NSF programs. The directive of the NSF enabling legislation (PL 507) as amended, "to appraise the impact of research upon industrial development and upon the general welfare," has been implemented through the years by continuing reports and surveys of the research activities of private industry and special attention to these areas in the series of National Science Board reports on "Science Indicators."

The NSF-Industry Relations Committee, established in 1971, provided the Foundation with a highly useful report in the spring of 1972. (See Attachment A, Appendix 2.) Many of the recommendations of this study were later implemented, particularly through the program of Research Applied to National Needs. The Federal role in support of industry was further examined in the 4th Annual Report of the National Science Board entitled "The Role of Engineers and Scientists in a National Policy for Technology" delivered to the Congress in 1972, and many aspects of the needs for research in industry were addressed in the 8th NSB Report, "Science at the Bicentennial, 1976."

p.1, P.3

The Senate Report (94-888) on its Fiscal Year 1977 Authorization Bill (S.3202) for NSF directed that a study be undertaken which would examine the roles and responsibilities of the Federal Government and, in particular, the National Science Foundation with respect to research and innovation in non-academic institutions.

p.1, P.4

In response to this request preliminary studies were undertaken by the Director's Office, and in July of 1976, the internal NSF Industry Task Force was established. This group, composed of senior officials from all NSF Directorates, was charged with undertaking a full and thorough examination of the issues raised in the Senate's Authorization Bill Report. The Task Force examined a wide range of existing studies of innovation and research in industry, and a special <u>ad hoc</u> consultant group (see Appendix 7 of Attachment A) was convened representing a broad cross section of United States firms and universities. Views of many additional research and corporate executives were solicited as the Task Force report passed through various drafts.

The preliminary Task Force Report (see Attachment A) was examined by members of the National Science Board and discussed at their meeting on November 18, 1976. This current report on "Research in Industry" thus reflects the views of members of the National Science Board and the NSF staff on the role of the Foundation in strengthening the National R&D effort as it relates to industrial research.

II. FINDINGS

p.2, P.2

The findings are listed in order of perceived importance to enhancing the contributions of industrial research to national purposes. Each item in this section is coupled with an "action" proposal in Part III.

A. Principal Findings

p.2, P.3

1. The primary role of the National Science Foundation in the national R&D effort is to continue the support of fundamental research of the highest quality in the basic sciences and so strengthen the total science capability of the Nation.

Discussion:

p.2, P.4, S.1
p.2, P4, S.2
p.2, P4, S.3
p.2, P4, S.4
p.2, P4, S.5
p.2, P4, S.6
p.2, P4, S.7
p.2, P4, S.8
p.2, P4, S.9

The Federal Government is and will continue to be the principal source of support of the basic sciences in academic institutions; for the generation of fundamental knowledge; and the education of research scientists. Both industry and the mission agencies of the Federal Government need new fundamental knowledge to make feasible the research and development that leads to desirable new technologies. Support of this mission-oriented basic research must be provided by the agencies of the government as well as by industry to ensure that innovation takes place which will meet the needs of the Nation. Underlying this, basic research in the problems of the scientific disciplines themselves provides knowledge that by its very nature is multi-directional and can lead to a variety of unforeseeable applications. Both industry and the mission agencies of government depend upon this fundamental knowledge from the scientific disciplines. This kind of basic research is carried out largely in academic settings. The academic environment is the unique source of new scientists and engineers in basic research, applied research, and development. The NSF has a singular and essential obligation to respond to the needs of research scientists in the basic disciplines. The most important role for the NSF is to assure the support necessary to enhance the potential of these basic science disciplines in academic institutions.]

p.3, P.1, S.1 [Basic research in the scientific disciplines provides a knowledge base that is necessary to the development of the new technologies sought by industry and the mission agencies.] p.3, P.1, S.2 [The difficulty of predicting particular applications, the very long times required for the conduct of the basic research to the point of utilization in technology and the fact that much of the benefit is diffused throughout society and not appropriable by any one firm, however, reduces the incentive for industry to support research in the basic scientific disciplines.] p.3, P.1, S.3 [As a result, the programs of the National Science Foundation provide a principal vehicle for the support of research of high quality in the fundamental disciplines of science.]

p.3, P.2, S.1 [It is also the obligation of the mission agencies to identify and support broad areas of basic research that in the long term may be important to their missions even though the exact relationship between the specific research projects and the mission may not be clear.] p.3, P.2, S.2 [Of course the mission agencies should also support research designed to build the knowledge base seen in the short term to underlie known applications in their areas of responsibility.]

p.3, P.3, S.1 2. [<u>The most effective means of strengthening industrial R&D is to decrease current disincentives and to increase direct incentives established by the Federal Government.</u>] p.3, P.3, S.2 [<u>The Federal Coordinating Council for Science, Engineering, and Technology in the Office of Science and Technology Policy should analyze the appropriate steps to be taken and assure full consideration of these at all levels responsible for Federal policy.</u>]

<u>Discussion:</u>

p.3, P.4, S.1 There is evidence of diminished funding of R&D in and by industry relative to the GNP. Consultants advise that a major shift in the application of R&D funds in industry is taking place toward "defensive research" dealing with federal regulations and toward shorter-range goals rather than higher-risk, longer-term research directed toward major innovations.

p. 4, P. 1

Specific actions to change the incentive structure are beyond the authority of NSF but studies and analyses of the potential impact of changes in the present incentive/disincentive structure are of high priority for sponsorship and support by the Foundation. Such study results must then receive serious consideration by the highest policy levels of government in order to ensure that undesired constraints on the innovations that flow from industrial R&D will be relieved and positive incentives will be strengthened.

B. Additional Findings

1. The present policy of NSF on funding research in industry is reaffirmed.

Discussion:

p. 4, sec. B

The existing policy states that in exceptional cases, unsolicited proposals for basic research will be considered from industrial organizations where: (a) the project is of special concern from a national point of view and shows promise of solving an important scientific problem; (b) unique resources are available in industry for the work; or (c) the project proposed is outstandingly meritorious.

The established special criteria for support of research in industry (Attachment B) as well as the existing affirmative programs to encourage industry/academic research collaboration express the current policies of the NSF.

Because of the inherent differences of academic and industrial settings; because the most effective measures for strengthening industrial R&D are alterations of governmentally determined incentives and disincentives; and because industry depends upon a vigorous and creative academic science community whose primary support is from NSF, the Foundation judges it to be inappropriate for the same criteria for funding of basic research by the National Science Foundation to apply both to industrial and academic settings.

2. Improved communication is needed between scientists working in universities, federal laboratories and industry.

Discussion:

The capability of industrial laboratories to provide practical applications for developments at the frontiers of science is heavily dependent upon communication between industrial and academic scientists who are familiar with the latest technology and active in related fields of basic research. Often the best way to transfer new basic knowledge and research techniques is to move academic scientists with the requisite expertise directly into the industrial laboratory. University faculty and research scientists can gain insight into industrial research problems through direct experience in industry laboratories. Conversely, industrial scientists can benefit from a period of work in a university basic research setting. Such exchanges of personnel take place now, but a strengthened effort to stimulate interchange of university and industry personnel would be valuable to both parties and to the Nation. Another important flow-through device is the conduct of joint research projects by university and industrial scientists. Such arrangements can capitalize upon the special skills and experience of both parties. A particular opportunity exists where research could provide improvements in processes or methods in those industries that do not have an extensive in-house research tradition or do not presently make significant research investments. Joint research projects with universities in this case could lead over time to substantial improvements in productivity and the international competitiveness of such firms.

3. Improved avenues of communication between industrial scientists and those responsible for the establishment of federal science and technology policy are needed.

Discussion:

Although industry is an important producer of basic science, it is also a major user and is dependent on the basic knowledge that is produced primarily in the academic setting. More particularly, scientists in industry have a unique ability to identify areas in which the lack of fundamental knowledge is impeding the development of technologies that are important to economic development and other national needs.

Probably the most important single scientific resource that the Nation has is the creative potential of young people now in our school systems who have the motivation and capability to become scientists. Roughly sixty percent of all scientists and engineers of the Nation are now engaged in industry and it is highly probable that this percentage will increase. For at least the next twenty years industry will be the principal location for the creation of new jobs for scientists and engineers. A greater understanding of industrial research and development could improve the match between the supply of scientific and technical manpower and the needs of industry. An enhancement of communication with industrial research in both planning and policy is needed by the federal mission agencies as well as the National Science Foundation.

A particular area for improved communication is that set of industrial activities that do not now support research to any significant extent. Only six industries account for some eighty percent of all forms of industrial R&D undertaken in the United States. The one hundred companies with the largest R&D programs account for nearly eighty percent of all of the industrial research and development undertaken by the thousands of companies that exist in this country. The nature of the science and technology-related problems confronted by the overwhelming majority of companies that do not do any research is poorly understood. The potential for improved productivity as well as for innovation of new products, processes, and services within this non-research oriented component of industry demands an improved level of study and communication.

4. <u>The smaller high-technology firms with large R&D commitments require special consideration in the policies of the Federal Government</u>.

<u>Discussion</u>:

New and small (often defined as less than 500 employees) high-technology firms with a heavy research and development commitment have been particularly effective in developing innovative products, processes, services, and increased employment possibilities. In part this is because of the inherent flexibility of a small organization that is capable of very rapid growth.

The availability of venture capital for the support of the growth of these small firms is judged by individuals from these firms and by consultants to be inadequate to meet the present demands. A federal initiative designed to take advantage of the innovative capacity of smaller research-based organizations might be in the national interest. While it is often asserted that private funding is not meeting the perceived needs of these firms, there is no general agreement about the actual amounts of funds available or needed. In part this funding could be facilitated by improving the opportunities of participation of such small firms in federal programs.

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Under any circumstances, it is desirable to recognize the particular needs of these firms and to enhance their opportunities to reach their potential as R&D performers and technological innovators. The risks are quite high, but so are the potential benefits of these small firms to the Nation in the development of useful new products, processes, and services and in the creation of potential items for export.

III. NSF ACTIONS

The following actions either are underway or under consideration by the National Science Foundation in response to the findings in Part II.

A. <u>The present NSF policy is to support basic research in industry directly when special criteria can be met. Major support to such research is provided indirectly through the output of academic research and education.</u>

<u>Discussion</u>:

The principal focus of the NSF program has been the support of researchers of the highest calibre, working on problems at the frontiers of the basic disciplines of science. For many reasons discussed earlier most such research occurs in the Nation's academic institutions. Although the majority of research scientists work in industrial laboratories, they are most often involved in problems whose origins are outside of the basic sciences themselves. Such user-oriented research is typically commercialized. Problems in such areas as property rights, patent policy, allocation of effort, etc., need to be resolved if such research is to be supported with public funds.

The present NSF policy of imposing special criteria on proposals from industry for basic research support continues to be the policy most beneficial to the overall strength of science in the United States at this time. There is, however, a range of opinion on this policy among the members of the National Science Board as well as the staff of the National Science Foundation. Because of this difference of opinion and because this policy can give the appearance of excluding one area of promising research capability, the National Science Foundation will periodically review the policy to determine if it continues to be appropriate.

B. <u>With a view to increasing industrial R&D in the national interest, a stronger emphasis should be given to programs that study the incentives and disincentives to increasing the level of industrial R&D. The results of such research should be vigorously disseminatec</u>

Stronger emphasis should also be given to the study of and experiment with the processes of innovation themselves and to the value of industrial innovation to the public interest.

Discussion:

NSF presently has several programs which touch upon the governmental framework for industry R&D, including Policy Research and Analysis (PRA), RANN, and Social Sciences. In PRA, in particular, many key research findings, bearing on the federal relationship to industry were funded under the aegis of the former National R&D Assessment Program and are just reaching fruition. Moreover, further work in this area is in process and planned. NSF will undertake to assess these results carefully and undertake to ensure that they are made available to the Office of Science and Technology Policy, other government agencies, and industry to ensure that possible policy changes that might benefit the Nation can be fully explored. Consideration will be given to expanding this program of studies.

Further, several experimental projects in the stimulation of innovation were funded under the former R&D Incentive Program and are being continued by RANN. Additional RANN projects are testing potential stimulants to innovation; NSF will undertake a systematic effort to analyze and evaluate these efforts and to disseminate the results widely.

C. A continuing awareness of industrial R&D and a recognition that it is an essential part of the Nation's capability in science will be part of the policy considerations of the NSF.

Discussion:

Although the present direct funding policies of NSF are appropriate, more attention needs to be devoted to increasing R&D in those industries that are already committed to major programs. It is also important to study the reasons for the lack of research in the vast majority of American companies and to identify ways to increase appropriate research and development programs.

In general, analysis of this problem must involve all agencies of the government as well as the policies and programs established by the Congress. The NSF role should be in supporting highly qualified investigators seeking to analyze the dynamics of industrial research and the distribution of its benefits.

D. Existing emphasis on cooperative university-industry research efforts will be continued along with programs to provide for personnel interchange between academic and industrial laboratories.

Discussion:

A wide variety of joint research efforts involving universities and non-academic performers are presently sponsored by NSF. These include both contractor-subcontractor relationships and arrangements of equal partners. Overall experience with these programs has been favorable. In some instances cooperation with industry is essential (e.g., research on industrial automation). Projects underway in RANN that bear on the private sector productivity almost always require industrial participation. Consideration will be given to expanding these programs after careful evaluation of their effectiveness.

In certain instances industry involvement has been taking place in basic research through workshops and through the Research Initiation Grants Program in Engineering. These efforts will be continued.

Consideration will also be given to an expanded program to provide for direct interchange of personnel between universities and industry using the fellowship mechanism.

E. Improved communication with industry on policy matters should be developed at the National Science Foundation and in other federal agencies.

Discussion:

The advantage of increasing the input from industry into planning and program development is substantial. It should be noted that the data presented in the Task Force Report (Attachment A, Appendix 5) clearly indicate that industry input in the present review and advisory processes is significant. Further input is, however, needed and NSF will consider the following options.

- expansion of involvement in existing advisory processes
- establishment of a separate Industry Advisory Council
- establishment of an industry component of the NSF Advisory Council
- development of special studies by industry on research needs and priorities

It is not at present clear whether any one of these steps or a mix of such steps is the best mode of obtaining the needed advice. Nevertheless, the Foundation is committed to increased communication with industry.

F. The special problems of support of small high-technology firms that are R&D intensive will be explored further.

Discussion:

Through legislative requirement a certain fraction of RANN funds have been devoted to support of small R&D firms. Prior to this requirement, RANN had already supported a significant number of projects at smaller firms. The response of small R&D firms to the RANN activity has been very positive and NSF is considering several alternative means to broaden the coverage of this program. Discussion with the consultants indicates that a major need of these firms is for innovation or venture capital for purposes of product development rather than research. This implies federal policy considerations outside the realm of NSF, however, the Foundation will continue to study the issues and develop policy options in this area.

In addition, the legislatively mandated Office of Small Business R&D has now been established and will assist appropriate small R&D firms to communicate with NSF programs. It is also expected that the work of the new Office may result in additional information relevant to review of current policies.

:ONCLUSIONS AND SUMMARY

'he Principal Findings of this report on pp. 2-4 far outweigh the Addi- ional Findings and other suggestions included in the attachments to this eport.

his comparison is not made to diminish the inherent importance of each f the findings or to suggest that the findings exhaust the opportunities r enhancing industrial R&D. Rather it is to focus emphasis and action i the first two findings which are overwhelmingly the most important.

Senator KENNEDY. Our next panel provides us an opportunity to learn about citizen involvement in scientific and technical policy issues.

The panel members have given careful thought to the role NSF can play in providing support to make available the scientific and technical assistance these groups need in order to participate in public policy debates today.

The first panel member, Tersh Boasberg, is an attorney who is concerned with public policy issues. Mr. Boasberg is the author of a report entitled, "Implications of NSP Assistance to Non-profit Citizen Organizations." I found it to be balanced and careful and extremely useful and I'm looking forward to hearing from him on his findings.

The second member is James Sullivan, co-director of the Center for Science in Public Interest. Dr. Sullivan has extensive first hand experience working with citizen groups and providing them with scientific and technological knowledge, and we welcome his comments.

Could we recess for just a minute.

[Off the record.]

STATEMENT OF TERSH BOASBERG, SENIOR PARTNER, BOASBERG, HEWES, FINKELSTEIN & KLORES, ATTORNEYS AT LAW, WASHINGTON, D.C., ACCOMPANIED BY JAMES B. SULLIVAN, PH. D., CO-DIRECTOR, CENTER FOR SCIENCE IN THE PUBLIC INTEREST, WASHINGTON, D.C.

Mr. BOASBERG. Thank you, Senator, I appreciate it.

I would like to thank your staff who has worked very closely with me. I think Anne Strauss has given generously of her time and added a great deal of balance to this report.

In the report we looked at over 400 cases and examples of nonprofit activities, statutes, articles, and so forth. I do want to say the report is not quite completed. All of the text is done. We are just check-to make his own conclusions on the basic questions in the report. I would like to make sure you know that the report does present both sides of the issues. My testimony today is the report does present both sides I will be glad to give you my own personal opinions.

I would like to summarize the report in a few words. I have managed to get the 250 pages on a small piece of paper. I do not think my contract officer would appreciate receiving this, but it is the same story of the fellow studying for a bar exam, who manages to reduce all his courses to one outline, reduces the outline to one piece of paper and then that piece of paper is reduced to an acronym, and then he gets to the bar exam and forgets the acronym. Luckily, we are able to bring in the acronym here.

A few points—one is, I think it is important to differentiate the proposed NSF program for funding citizen groups from intervenor bills. A lot of the people interviewed thought that what we were really doing was proposing to fund intervention. It is very clear to me that what you are proposing is funding technical studies for groups—you mentioned it twice in your opening statements of last Tuesday and today. You are not funding attorney's fees, you are not funding court costs. This is not a concealed bill for intervenors, and I think that is very important.

Second, we have heard a lot of talk about advocacy—where science lets off, advocacy begins—

Senator KENNEDY. Would the argument be that you are giving them scientific information and data which they would use as intervenors?

Mr. BOASBERG. Well, I think that the important point to remember, Senator, is that there are 3,800 groups, nonprofit groups, that we know of today. Of those 3,800, very very few get into intervention. The ones that get into formal interventions are the ones that we all hear about, the ones that grab the headlines and so forth, but there is simply not enough money proposed which will change that general non-intervenor pattern.

The second point is that in intervention, as you know 50 percent of the costs, at least, are attorney's fees. Let me just give you two examples. ConEd has spent $575,000 in legal fees alone, on one project. And in the answers that you received in your hearings last year on S. 2715, the ICC paid $1.3 million to two Washington, D.C. law firms who appeared before it as special counsel.

Now I think that your own proposal is talking about must less than $25-$40, 50 million.

The other point is that we heard a little bit from business and industry today—the fact of the matter is that $8 billion in Federal funds is going to business and industrial research. Now I do not think anybody is saying that that money is encouraging business and industry to intervene, and of course, there are no limits placed on such Federal funds regarding intervention.

You are talking about less then one-tenth of 1 percent possibly going to citizen groups.

And, the last point I want to make is that the idea of giving these groups funds for studies is to get information to them at an early point in the process, when the study can inform them about the scientific merit of their proposal, and I think there is just as much a chance that the study will inform the group and not lead to intervention as there is that few of them might lead to intervention. But I really do not think that is the point.

Senator KENNEDY. Can you show where that bar happened as a result of scientific and technical information being available to various types of groups.

Mr. BOASBERG. I know that Jim Sullivan might be able to speak in terms of giving groups early access to materials and——

Senator KENNEDY. This is obviously the question that we are going to face and that is why we are trying to get answers from two people that have thought about it probably as much as anybody in the country.

Dr. SULLIVAN. I can give two short examples of that.

As I will mention later, our group provides technical assistance to citizen groups, and one program that we have had for a number of years is called the Science Matching Service to link up scientists with local citizen groups. Let me describe one particular example—a citizens group in the District came in to us and said, "We are concerned that the milk that we drink here has high bacteria counts." They had read items in Consumer Reports and other places, that possibly there might be a problem with the milk supply and their members had thought that that was a good issue that they should bring up. They wanted to intervene at the District level here to get the Consumer Affairs Office and Health Inspectors to go out and monitor milk. We linked them up with a few biologists and chemists and it took about two hours for them to realize there was not any problem with the milk. And without that kind of technical input, they would have gone ahead and caused quite a fuss at the local scene here, about the problems with milk.

Another example, I think, is some of these nuclear power controversies. The *Seabrook* case, for example, in New Hampshire—if you look at the early record of that controversy, you see a lot of jockeying about issues that just were not technical issues at all. One example is that citizen groups have so little funds to intervene in a nuclear energy intervention that they have to use the other sides' witnesses to bring out their own technical points. I have been a witness in a number of cases and I know that the No. 1 rule for a witness is never give anything to the other side. So, you can imagine what it is like for a public interest attorney to try to bleed a power company attorney to get out the facts that he needs to make his points. Whereas, if he had his own information at hand, he could make that argument directly and cut all of that jockeying back and forth that takes place in the intervention process. And that would materially shorten the debate on that.

Those are just two examples, but there are others.

Mr. Boasberg. I think there are two other points you ought to make about intervention—one is, the only reason people are against intervention is because it might cause delay. There is nothing wrong with citizens voicing their right in front of agencies just like everybody else. The delay factor was simply blown out of the water by the latest CEQ report. As that Government agency reported in October, in 6 years of experience with NEPA, there were 332 cases brought, and they were not all brought by citizen groups. They were brought by business and industry as well. Of those 332 cases, only four resulted in a permanent injunction, and of those four, not a single project was delayed after it had complied with the law—after it complied with NEPA.

The second point I want to mention is that the agencies have so many interests already before them that even if they had one or two public intervenors, public citizens, it is not going to make a difference, and I cite two examples—one is the clear channel proceedings, which you are probably familiar with at the FCC—this is Docket No. 6741, and it went on intermittently for 23 years, produced 30,000 pages of testimony, had 220 industry spokesmen and 7 nonprofit representatives. The longest hearing in the AEC's history (now the NRC), lasting about 160 hearing days and consuming 26,900 pages of testimony, had not a single intervenor in the entire case. I think the intervnor issue is completely overblown and we point to some of these statistics in the report.

The other major point that I want to make, Senator, is that all the agencies and all the States, as well as the Federal Government, talk about public participation—they encourage public participation. Citizens are encouraged to come in to comment on regulations and speak. But, the outstanding fact is that they cannot do this without any funds and the National Commission on Water Quality, for instance, talking about the FWPCA—the Federal Water Pollution Control Act amendments, which had extensive provision for citizen participation, more so, perhaps, than any other Federal statute—their conclusion was that citizen groups were not participating because they lacked the funds for technical sources.

Let me make a few other points.

One, is that I think that when we talk about granting money to citizens groups, people think of just environmentalists. I think it is important to remember that we are talking about all kinds of citizens groups—those that are in favor of, as well as against, nuclear plants, those who are in favor of, as well as against power installations—and they come in all colors and all persuasions, and I think this program should be open to all of them.

And then, the last point I would like to say is that there is a lot of concern that this is going to lead the National Science Foundation into a political quagmire. It seems to me that science is not a newcomer to controversy—that our chief science agency should not avoid the most pressing public policy issues of today, and frankly, I am impressed with the staff, the quality of people they have, and I think that they are the natural agency to carry it out.

I would like to answer any questions that you would have.

Dr. SULLIVAN. Senator, I have a written statement which I will not read, but submit for the record. I will just try to touch a few of the highlights of it.

[The prepared statement of Dr. Sullivan follows:]

Statement of James B. Sullivan, Ph.D.

Co-Director, Center for Science in the Public Interest,
Washington, D.C.

Subcommittee on Health and Scientific Research
Committee on Human Resources
U.S. Senate

National Science Foundation Authorization Hearings
March 3, 1977

I am Dr. James Sullivan, Co-Director of the Center for Science in the Public Interest. CSPI was founded in late 1970 to serve as a science "back-up" center for consumer, environmental and other public interest groups, and to work with citizen groups in promoting consumer safety and environmental protection. Issues the Center has been involved with include food safety, toxic chemicals, energy issues, air pollution, noise and water pollution.

Based on CSPI's experience, I firmly support authorization of the Science for Citizens program. It begins to fill an important need that until now has been ignored. I would like to describe the Center's activities in one area, air pollution, to demonstrate that need to you.

CSPI has worked with several dozen citizen groups on the issue of highways and air pollution. We have been involved to some degree in the majority of major highway controversies throughout the country during the past six years: I-66 in Arlington, Virginia; the Three Sisters Bridge and I-95 in the District of Columbia; the West Side Highway in New York; the Wilbur Mills Freeway in Little Rock, Arkansas; Brackinridge Park in San Antonio, Texas; Wildwood Park in Harrisburg, Pennsylvania; I-410 in

New Orleans, Louisiana; the proposed southern crossing to San Francisco; I-64 in Charleston, West Virginia, and others.

On air pollution from power plants we have worked with citizen groups in Maine, Massachusetts, New York, Maryland, Arkansas, Texas, Arizona, Utah, New Mexico, Nevada, Calfiornia, and other states. You can see from these lists that the need for technical assistance is widespread.

The question raised in all these cases was the same; would the proposed new facility cause air quality to fall below primary standards establsihed under the Clean Air Act. Most cases involved reviewing state or federal environmental impact statements from a technical point of view, that is, whether the statements' technical assumptions, methods, and conclusions were of high scientific quality. Complex meteorological and pollution diffusion models were used in the statements.

A large number of these studies amounted to little more than promotional borchures for the agency's project. In critiquing these studies CSPI repeatedly encountered similar shortcomings: neglect of topics required by statute or regulation; improper, incomplete or invalid modeling of pollution or economic impacts; ample discussion of the beneficial impacts of a project with little or no discussion of negative impacts; no discussion of alternatives to the project; neglect of long term consequences of the action. While some studies were objective and comprehensive, more were biased and self serving. While some studies showed a good deal of effort and attention to detail, many others were obviously prepared to satisfy just one more piece of bureaucratic red tape. In fact, a survey of highway impact statements conducted by CSPI uncovered statements which were copied word for word and page for page from statements for different projects in other states. In short, the statements critiqued by CSPI were far from objective and did not increase understanding of the environmental impacts involved in the projects.

From this experience, I draw several conclusions:

(1) First, there is a clear and pressing need for the Science for Citizens program. The individual citizen is rendered powerless by the technical impenetrability of state and corporate enterprise. Can lay citizens influence the debate over food additives or electric utility rates when those debates hinge on complex biological or economic questions? Citizens concerned with air pollution are faced with intricate pollution modeling methods. How many citizens are familiar with Gaussian functions, logarithmic distributions, or exponential decay? Yet on these concepts depends whether or not the citizen loses his or her home to a new freeway. Without technical assistance, such as that provided by Science for Citizens, clean air groups will not be able to participate in government.

(2) Second, advocacy citizen groups can and do produce excellent objective research studies. Most of CSPI's cases involved litigation, licensing or other form of advocacy intervention. The Center's activity involved critiquing studies prepared by state or federal agencies proposing the projects.

CSPI's input, I am certain, would be classified by any scientific observor, as being objective--even though our work was instigated by citizens involved in an adversary type proceeding. I believe the Center's critiques were helpful in providing the decision makers with a broader understanding of the technical issues involved. Hence, we contributed to a sounder decision.

The implications of these conclusions for the Science for Citizens program are as follows:

(1) Science for Citizens should be authorized for FY 1978 at a higher level than the $1.2 million authorized for FY 1977. This amount is hardly sufficient to develop enough experience to develop a good program. The $3 million suggested in last year's Senate bill comes closer to what is needed for a sound program.

(2) Citizen advocacy groups should be solicited and encouraged to apply for Science for Citizen funds. Under no circumstances should citizen advocacy groups be excluded. A citizen;s right to participate in government includes the right to seek judicial review. Concern for special interests should not undermine or abrogate basic rights to participate in government.

Many citizen groups with which I have spoken mistakenly believe that the Science for Citizen program will not fund advocacy groups. An article in <u>Televisions</u>, a media oriented newspaper, calls the program a "science for scientists" program. I attribute part of this citizen error to NSF project descriptions used to announce the program. Perhaps unwittingly, NSF has given the impression that only professional societies and scientists can apply for these funds. One example is the public hearings held last year on the program. They were held in science museums and not in community assembly places like school auditoriums or civic centers. The hearings also requested that citizens testifying prepare written statements in advance before attending the hearing, hardly an activity familiar to lay citizens. These procedures have fostered the notion among citizens that the program is not for them but for experts. NSF should remedy this with language and procedures that are familiar to all citizens.

(3) My last suggestion for NSF is to develop what I would call citizen technical back-up centers. The back-up centers would provide services similar to CSPI's technical assistance programs which I described for air pollution. The centers should be developed as a logical follow-up to the current Science for Citizens conferences and fellowship programs.

The back-up centers, under the direction of grass roots citizens, would fund local citizen groups so that they might hire scientists and engineers to help them understand the technical aspects of public policy issues. For example, the centers might fund an environmental group to hire an aquatic biologist to critique an impact statement on a new dam. Urban minority groups might get funds for an economist to analyze and critique cost benefit studies for urban renewal plans. Local and state legislators could hire an engineering consultant to help them develop solar energy legislation for their area.

Technical experts would be recruited from local universities and other private institutions. The staff of the back-up centers would consist mostly of community organizers and managers who would link up citizens with specialists who can provide the needed technical assistance.

Several private organizations--CSPI, the Institute of Ecology, the Scientists Institute for Public Information, several professional socieities--have developed experiences in this area which could be tapped by NSF in developing the science back-up center concept. I could say much more about this back-up center concept but I don't have the time here. I would be happy to explain the concept in more detail if you wish. I suggest that the Foundation begin study of this concept now in order to begin possible activity in FY 1979.

Thank you for inviting me to testify today. I would be glad to answer any questions you may have.

Dr. SULLIVAN. My basic contribution, I think, to these hearings is the experience I have had with citizen groups who are involved in public policy debates. I have, in my testimony, listed some of those groups in one area—air pollution. You can see from that list that they are all over the country. My academic training is in meteorology, and I cannot handle the volume of requests that I get for assistance from citizen groups who do not understand the environmental impact statements that their State Agencies have prepared or Federal Agencies have prepared. My experience over the past 6 years is that this Science for Citizens program is crucial from a citizen participation point of view.

The National Science Foundation should be well aware that this program is also critical, I think, from the point of view of making these environmental impact statements and technology accessments have high scientific quality.

The Center for Science in the Public Interest has reviewed the first 100 environmental impact statements that were filed under the Environmental Policy Act back in 1970. We found that most of the reports were little more than promotional brochures for the projects at hand. Similar shortcomings were in each statement.

We listed all of the different issue areas—air pollution, noise, water, land, et cetera—land use—that were required by regulation to be considered in these statements, and invariably, they were lucky if the statements covered 30 or 40 percent of those topics—even discussed them or mentioned the name of the topic. I can give you an example—in Little Rock, in a highway case, an aquatic biologist did all the air pollution work. He had gone to a 5-day course with the Highway Administration to learn how to use these equations. The work that he did would not pass a first physics course in college.

One other striking example that was very unexpected that we discovered—is that many of those statements were literally copied, page for page and paragraph for paragraph, copied from statements for other jurisdictions, other projects. They would just take the statement from another State, change the name on the front from I–15 to I–20 and submit it as being their own environmental impact statement.

This kind of shoddy work just should not be acceptable to any person who believes in a rational decisionmaking process. I think the NSF, with this Science for Citizens program, can insure that those statements are going to improve in quality. Let us face it—the only thing that makes an environmental impact statement accurate and complete is that other people are going to critically read the statement when it is finished.

So, from these experiences, I see a clear and pressing need for the Science for Citizens programs. Last year's budget, fiscal 1978 budget of $1.2 million is, in my opinion, gross underfunding for such an important program. I would suggest that the $3 million suggested last year in your bill comes closer. I would like to see even more funds, but $3 million comes closer to what I think is necessary.

Senator KENNEDY. Well, you are aware of what happened over in the House?

Dr. SULLIVAN. Yes—the complete removal of any program funds for fiscal 1978. I just do not understand that. It seems to be a very irresponsible and parochial, narrow point of view, based on the interest of several members of that committee.

I do not understand, really, how that happened.

Mr. BOASBERG. They have not seen my full report, Senator. [Laughter.]

Dr. SULLIVAN. Especially at this time when closed Government and distant, removed Government is such an issue, The House action smacks of a removal of citizens from Government, and keeps the decisions in the hands of the technical elites. That seems to me, politically, to be a very unwise move on their part.

The second conclusion I would like to draw beyond the need for the program, is that advocacy citizen group—and NSF should make a commitment to this—that advocacy citizen groups can and do produce excellent objective research studies, and that they should in no way be excluded from NSF funds. It does not mean that NSF should fund biased research. It means that NSF would fund objective research by groups that perhaps may advocate a position.

NSF needs to make a commitment that they will not exclude public interest law firms or similar groups, Sierra Clubs, Friends of the Earth kind of groups, from the funding process.

My last suggestion, in light of yesterday's Home action, might be premature, but I will make it anyway. NSF should develop what I call citizen technical backup centers. This is an extension of the present forums, conferences, and workshops and fellowship programs that NSF now has. The Foundation should develop backup centers which would provide services similar to what I and other scientists at the Center for Science in the Public Interest have been doing by providing technical assistance to citizen groups.

Basically what we do at our Center is spend some time with citizen groups to find out what the technical problems are and to hone in and to phrase their problems in technical terms, take those technical questions to university researchers or any private think-tank researchers, and try to get the question answered for the citizen groups.

This activity is not possible under the present NSR authorization for the two programs that they have so far. For fiscal 1979, NSF should have such backup centers in operation. The centers would have program managers much the same way the Office of Technology Assessment has program managers that would work with the citizens' group and then give NSF funds directly to the citizens' group for them to hire university researchers. So, you would have top quality academic and private researchers working on these citizen problems.

Those are my suggestions. I thank you for inviting me and I will answer any questions that you might have.

Senator KENNEDY. Well, I think the obvious issue which we have to address is the issue of delay. I think that your report, Mr. Boasberg, addresses the issue in very considerable detail. Does this information result in bringing more information of a technical and scientific nature into the public debate or is it just used to bring irrational delays to the process and the system. That is the problem we have to deal with. You go into very significant detail on that. You analyze the history of this issue, and I think illustrate where that delay has not been the case. You have also pointed out a number of instances, where you feel the whole process was expedited. I think that is going

87-769 O - 77 - 21

to be the nub of this very important issue, both in regard to scientific and technical assistance and in regard to attorney fees legislation.

Mr. BOASBERG. If I might say on that point, Senator, that the Nuclear Regulatory Commission, as you know, just decided against funding intervenors. They made an exhaustive study and they concluded that there was no way of telling whether intervention led to delay or not. This is the NRC, itself, which is the hotbed of all the claims against delay. Their own decision said that the question of delay was just tremendously speculative.

The other point is that if we have an agency process—if the agencies are making decisions—if, like the NRC, they have a mandate of public hearing—I mean, their hearing is mandated by law, whether there is any intervention or not—they have to have a public hearing on nuclear power plants.

It seems to me the point of your bill is that you are going to give people an opportunity to constructively help decisionmakers. Your point is to get scientific, high quality studies into the decisionmaking process from citizen organizations of both persuasions—of both—people that think this is a great idea because they will get lower energy costs and those that are against it for enironmental reasons and other things. But, your point seems to me, is to help the decisionmakers by giving them the value of these studies the same way as the private interests are theoretically helping the decisionmakers by giving them the value of their research.

So, I think that to me that the point is that you are trying to aid public policy decisionmaking by studies of high quality.

Senator KENNEDY. Now, how do we get back to the point that that is what the agency is supposed to do itself and that we do not need intervention if the thought and care has been given to appointing members of these agencies. They are charged with carrying on the public interest and why do we need, if they are doing their jobs, this additional intervention?

Mr. BOASBERG. Let me just mention a couple of things on that.

One, is—the agencies themselves—and you have educed this in your hearings on S. 2715 and S. 270—the agencies themselves have asked for input of citizens organizations to help them identify the public interest, because they interests are not monolithic. I mean, the FTC intervenor funding proceedings do not fund just one intervenor. They fund seven, eight, ten intervenors. There are so many different interests to represent.

We have some testimony from the Consumer Products Safety Commission, the California Commission and so forth, saying that what we really need is—we have got all of the industry points of view, we have got all the private interests—but we are only human beings. We have to hear from the other side as well.

So, I think that the agency must decide in the public interest and in order to make that decision, they need representatives from all of the interests that are affected. I mean, the agencies themselves have admitted that.

The other thing is that there are conflicts between agencies. We have a case where the Environmental Protection Agency sued the Department of Agriculture. Now, theoretically, both agencies represent the public interest, but both of them obviously felt that the public interest was actually on their side of the line. There are cases all the time where States and local communities are using the Federal Government or vice versa—this last case that you saw on offshore oil leases off the Atlantic Ocean involved a suit brought by States and local communities, who, theoretically, also represent the private interest. In *Seabrook*, the intervenors were the States of Massachusetts and New Hampshire, and the public interest in New Hampshire was divided because there was somebody representing the Governor and somebody representing the attorney general—both persons claim that they represent the public interest of the citizens of New Hampshire.

So, I think that the interests are so diverse that the agencies need help in obtaining deteailed information on all of them and they have admitted that.

Senator KENNEDY. Why not carry this, then, a further step and fund various groups themselves rather than just setting up a panel to bring scientific information.

Why not extend funding to various groups that would be involved. Then the responsible agency could hear their arguments and make a decision on the merits of the case.

Dr. SULLIVAN. That was my third suggestion.

I think we should imitate the Federal Highway legislation, which requires on Federal highway funds, that 1½ percent be spent on research. There should be a small percentage set aside on Federal program money to encourage citizen participation. Some of that money could go toward funding citizen groups to get technical expertise.

Mr. BOASBERG. Are you talking about groups who—like public counsel groups or groups actually helping the agency themselves, or citizen organizations who are separate from the agency themselves?

Senator KENNEDY. I am saying citizens organizations that are separate and raise public policy issues in regulatory proceedings.

Mr. BOASBERG. Well, I think that is it.

I mean. let us face it. That is where you get your diversity is funding your citizen organizations themselves. They are the ones that have the genuine concern. They are the ones who do the study and they can raise the points independently of the other agencies and of the other interests, and I think that is really what you are doing.

It is not unlike what we did about 10 years ago on the so-called legal services program. There, there was a rather small injection of funds and it really established a whole movement of public service laws. I think this could do the same thing by the injection of funds, establish opportunities for researchers and people to work outside of in a university or business setting. I think it could almost be a new careers type of program.

[The prepared statement of Mr. Boasberg follows:]

Senator KENNEDY. OK.

We are wrestling with this issue in the the Judiciary Committee, with a different vantage point, but these matters are related. I think there is probably some confusion on the part of my colleagues in the House as to what, really, the NSF has done in this area, and it seems to me that from all the studies reviewed in your report and the figures you have shown that it has been a very, very cautious approach and it has been extremely useful and very valuable—and really, quite limited.

But, whether we are going to be able to persuade our colleagues over in the House on this issue is something else again.

We have Dr. Rich here, who is a member of the Board and a valued constituent and distinguished scientist and researcher as well. He has followed the testimony in the hearing this morning.

Is there anything you would like to say, Dr. Rich? I did not definitely expect to call you, but would you like to make a brief comment before we conclude?

Dr. RICH. I can make a brief comment about the subject of the preceding panel.

STATEMENT OF DR. ALEXANDER RICH, WILLIAM THOMPSON SEDGWICK PROFESSOR OF BIOPHYSICS, MASSACHUSETTS INSTITUTE OF TECHNOLOGY, MEMBER, NATIONAL SCIENCE BOARD

Dr. RICH. There is considerable concern among members of the National Science Board about the decreasing participation of industry in the national basic research effort. We have been addressing ourselves to various possible programs that might help to reestablish vigor in that general area.

There are three kinds of issues here. One deals with basic research activities in industry. Another is the coupling between basic research in industry and basic research in academia, and that relates to the question of the rapidity with which discoveries are reduced to practical developments.

The third problem that we are concerned with is the special case of small industries which have a rather important catalytic role in research developments. Very often small groups of scientists form an industry and they are often at the cutting edge in applying new technological development. We are considering the extent to which the Foundation can make a contribution in that area.

I would summarize by saying that this is an area in which we are very interested and are considering at length.

[The biographical sketch of Dr. Rich follows:]

Biographical Sketch
DR. ALEXANDER RICH
William Thompson Sedgwick Professor of Biophysics
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Dr. Alexander Rich, William Thompson Sedgwick Professor of Biophysics in the Massachusetts Institute of Technology Department of Biology, is best known for his research which has helped map the structure of genetic material.

Born in Hartford, Conn., in 1924, Dr. Rich served with the U.S. Navy from 1943 to 1946. He received the bachelor of arts degree in biochemical sciences, magna cum laude, from Harvard University in 1947, and was awarded the degree of Doctor of Mecicine, cum laude, by Harvard Medical School in 1949.

From 1949 to 1954, he was a research fellow in chemistry at Gates and Crellin Laboratories at the California Institute of Technology. He was a visiting scientist at the Cavendish Laboratory in Cambridge, England, in 1955-56, and served as chief of the section on physical chemistry at the National Institute of Mental Health in Bethesda, Maryland, from 1954 to 1958.

In 1958 Dr. Rich was appointed associate professor of biophysics in the M.I.T. Department of Biology. He was named professor in 1961 and in 1974 was named William Thompson Sedgwick Professor of Biophysics.

The Sedgwick Professorship was established in 1964 in honor of William Thompson Sedgwick, the first head of M.I.T.'s Department of Biology in 1889. Professor Sedgwick was a distinguished teacher and investigator in bacteriology and public health, and is often referred to as the father of epidemiology.

At the time of his appointment as Sedgwick Professor, Dean Robert A. Alberty of the School of Science said that "Professor Rich has made major contributions to the knowledge of the molecular structure of biological materials, specifically nucleic acids and proteins. He is perhaps best known for the determination by him and his research group of the three-dimensional structures of transfer RNA, an important molecule in the living cell's protein synthesis machinery."

Using x-ray diffraction analysis, Professor Rich and his associates have been able to deduce the structure of the transfer RNA molecule to a resolution of less than three 10 billionths of a meter. Thus, they have been able to "see" the individual units making up the molecule and to improve the theories about how this molecule functions in the living cell.

In earlier work, Professor Rich and his colleagues discovered that proteins are assembled on clusters of protein synthesizing organelles which he

--more--

called polyribosomes or more simply polysomes. From all this work we now have considerable information about how proteins are made in living cells.

Dr. Rich has worked with the National Aeronautics and Space Administration since the late 1960s. He was a member of the Lunar and Planetary Missions Board from 1968-70, and since 1969 has been a member of the biology team for the Viking Mars Mission. From 1970 to 1975 he was a member of the Life Sciences Committee. In recognition of his varied service to NASA, Dr. Rich was awarded the Skylab Achievement Award in 1974 and the Theodore von Karman Award in 1976 as a member of the Viking Science Team.

He is a member of the National Academy of Sciences, and since 1973 has been chairman of its Committee on USSR and Eastern Europe Academy Exchange Program. Dr. Rich is a Fellow of the American Academy of Arts and Sciences, and from 1967-71 was chairman of its Permanent Science Committee. Since 1974 he has been chairman of the Academy's Nominating Committee. In 1976 he was appointed by the President and confirmed by the U.S. Senate for a six-year term on the U.S. National Science Board.

Dr. Rich is also a Fellow of the American Association for the Advancement of Science, and he was a Fellow of the National Research Council from 1949-51. In 1963 he was a Guggenheim Foundation Fellow and was named to Phi Beta Kappa in 1946.

Dr. Rich is a member of several scientific societies. These include the American Chemical Society, American Crystallographic Society, Biophysical Society, American Society of Biological Chemists, and the International Society for the Study of the Origin of Life. He is also a member of the Corporation of Marine Biological Laboratory, Woods Hole, Mass.

The author of over 200 publications, Dr. Rich was co-editor with Norman Davidson of a book, Structural Chemistry and Molecular Biology (Freedman and Co., San Francisco, 1968). His other publications are in the fields of molecular structure of the nucleic acids and their components, the physical chemistry of nucleic acids and polynucleotides, the molecular structure of proteins, the mechanism of protein synthesis, molecular biology of the nucleic acids, x-ray crystallography and the origins of life.

Dr. Rich has been on the editorial board of many scientific journals, including Proceedings of the National Academy of Sciences (since 1972), Journal of Molecular Biology (1959-66), Biophysics Journal (1961-63), Science (1963-69), Biopolymers (1963-74), Currents in Modern Biology (1966-72), Analytical Biochemistry (since 1969), PAABS Revisita (since 1972) and Bio-Systems (since 1973).

Dr. Rich and his wife have four children and live at 2 Walnut Avenue, Cambridge, Mass.

Born Hartford, Connecticut, November 15, 1924. Married: July 5, 1952: four children.

Positions

William Thompson Sedgwick Professor of Biophysics, Massachusetts Institute of Technology, 1974-present

Professor of Biophysics, Massachusetts Institute of Technology, 1961-present

Associate Professor of Biophysics, Massachusetts Institute of Technology, 1958-1961

Visiting Scientist, Cavendish Laboratory, Cambridge, England, June 1955-January 1956

Chief, Section on Physical Chemistry, National Institute of Mental Health, Bethesda, Maryland, September 1954-June 1958

Research Fellow, Gates and Crellin Laboratories, California Institute of Technology, Pasadena, California, October 1949-August 1954

Education

Harvard Medical School M. D. (Cum Laude) 1949

Harvard College A. B. (Magna Cum Laude in Biochemical Sciences) 1947

Military Service

U. S. Navy, July 1943-January 1946

Honors

Skylab Achievement Award, National Aeronautics and Space Administration, 1974

Member, National Academy of Sciences, 1970

Fellow, American Association for the Advancement of Science, 1965

Fellow, Guggenheim Foundation, 1963

Fellow, American Academy of Arts and Sciences, 1959

Fellow, National Research Council, 1949-1951

Phi Beta Kappa (Harvard College), 1946

Theodore von Karman Award for Viking-Mars Project, 1976

Membership on Editorial Boards

Editorial Board, Proceedings of the National Academy of Sciences, Wash. D. C., 1973-present

Editorial Board, Molecular Biology Reports, 1974-present

Editorial Board, Bio-Systems, 1973-present

Editorial Advisory Board, PAABS Revista, 1972-present

Editorial Advisory Board, Analytical Biochemistry, 1969-present

Editorial Board, Science, 1963-1969

Editorial Board, Currents in Modern Biology, 1966-1972

Editorial Board and Editorial Advisory Board, Biopolymers, 1963-1974

Editorial Advisory Board, Journal of Molecular Biology, 1959-1966

Editorial Board, Biophysical Journal, 1961-1963

Committee Membership

Scientific Advisory Board, Stanford Synchrotron Radiation Project, Stanford University, Stanford, California, 1976-present

Advisory Board, Academy Forum, National Academy of Sciences, 1975-pres

Chairman, Nominating Committee, American Academy of Arts and Sciences, 1974-present

Member of the Biology Team, Viking Mars Mission, National Aeronautics and Space Administration, 1969-present

International Research and Exchanges Board, American Council of Learned Societies, New York, N. Y., 1973-present

Chairman, Committee on USSR and Eastern Europe Exchange Program, National Academy of Sciences, 1973-present

Visiting Committee, Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1972-present

Member of the Corporation, Marine Biological Laboratory, Woods Hole, Mass., 1965-present

Member of the Lunar and Planetary Missions Board, National Aeronautics and Space Administration, 1968-1970

Member of the Council, American Academy of Arts and Sciences, 1967-present

Chairman of the Permanent Science Committee, American Academy of Arts and Sciences, 1967-1971

Member of the Life Sciences Committee, National Aeronautics and Space Administration, 1970-1975

Member of the National Science Board, 1976-present

Member of the U. S. National Committee, International Organization for Pure and Applied Biophysics, National Academy of Sciences, 1965-1967

Committee on Career Development Awards, National Institutes of Health, Bethesda, Md., 1964-1967

Visiting Committee for Biology Department, Weizmann Institute of Science, 1965-1966

Executive Committee, Division of Biological Chemistry, American Chemical Society, 1962

Member of the Council, Biophysical Society, 1960-1969

Visiting Committee for Biology Department, Yale University, 1963

Committee on Exobiology, Space Science Board, National Academy of Sciences, 1964-1965

Advisory Council, American Foundation for Continuing Education, 1962-1966

Postdoctoral Fellowship Board, National Institutes of Health, Bethesda, Md., 1955-1958

Society Membership

American Chemical Society, American Crystallographic Society, Biophysical Society, American Association for the Advancement of Science, International Society for the Study of the Origin of Life, American Society of Biological Chemists

Publications

Author of over 200 publications in the field of molecular structure of nucleic acid components, nucleic acids and polynucleotides, physical chemistry of nucleotides and polynucleotides, molecular structure of proteins, mechanism of protein synthesis, molecular biology of the nucleic acids x-ray crystallography, origin of life. Book: Structural Chemistry and Molecular Biology, Ed. by Alexander Rich and Norman Davidson, Freeman and Co., San Francisco (1968).

87-769 O - 77 - 22

Senator KENNEDY. Well, we will want to work with you and review and study this testimony and obviously look at these suggestions.

The board has not reached any decision about the budget cuts, have they?

Dr. RICH. Well, we have just learned of them, and we have not had any formal discussions about them as yet.

Senator KENNEDY. OK.

Mr. Boasberg, a final question—did you review the quality of the scientists themselves and the work that was being funded?

Mr. BOASBERG. Well, we looked at secondary sources, Senator, but we pointed out the studies that were conducted by nonprofit groups—many of those studies were picked up by Government agencies themselves. A number were followed by the National Academy of Science and we referred to Dr. Von Hippel and Jim Sullivan and a number of other people who identified studies in pesticides, herbicides, water pollution, health, food additives and so forth—many of these studies actually changing, as you well know, what our former thinking was about these areas, and have been followed with very serious research in the Government agencies themselves and by the National Academy of Sciences and we do point that out.

Senator KENNEDY. OK.

I think that about does it.

Thank you very much.

[The following additional statements were subsequently supplied for the record.]

Testimony

for

the American Mathematical Association of Two Year Colleges

by

Dr. Joseph E. Cicero
President - AMATYC
Clayton Junior College
Morrow, Georgia 30260

before the

Subcommittee on the National Science Foundation

of the

Committee on Labor and Public Welfare

United States Senate

March 3, 1977

AMATYC

American Mathematical Association of Two Year Colleges

Mr. Chairman, members of the Subcommittee and Staff, I am Dr. Joseph E. Cicero, Professor of Mathematics at Clayton Jr. College, Morrow, Georgia, and President of the American Mathematical Association of Two Year Colleges. Thank you for the opportunity to testify at this hearing.

The Two Year College has long been the stepchild of higher education. Although that image has generally turned around and Two Year Colleges are now thought of as an idea whose time has come, there are vestiges of the earlier tradition that continue to survive. In part, that is what prompts this testimony. There is also a strong desire to stress the affirmative nature of the American Mathematical Association of Two Year Colleges in meeting the needs of the Two Year College mathematics teachers and, more importantly, the students they serve. The Association is dedicated to preserving the finest traditions of mathematics education and higher education itself and to promoting responsible educational programs to meet the needs of the modern student in a technological society. Our aim is to provide a service to the vast community of students enrolled in Two Year Colleges, by providing a unified national voice for a segment of the people who serve them: their mathematics teachers. It is the feeling of the membership of AMATYC that today's society requires a sense of ease with mathematics on the part of all jobholders, not just those in the professions.

Since it appears that fifty-five percent (55%) of the American

College population is beginning its higher education at Two Year Colleges, I wish to stress the great concern I have with the issue of whether or not the Two Year College majority will occupy a major focus in the National Science Foundation's fine collection of National curriculum programs. In testimony presented to the House Subcommittee on Science, Research and Technology on February 9th of this year, the Science Education Directorate stated, "Given our operating procedures and given completion of most of the large-scale, older pre-college curriculum development projects, awards consequently will be for considerable smaller amounts than in the past". Regardless of whether or not the Foundation has decided that its mission is completed for students at other levels or in other disciplines, it has yet to begin in the area of Two Year College mathematics students. The education in the computational sciences of fifty-five percent (55%) of America's college students certainly deserves better support.

In the important area of peer review of educational project proposals, there is, in our ranks, great concern at the present time that proposals for support for Two Year College mathematics projects from the National Science Foundation are reviewed and evaluated by mathematicians who are unaware of the needs and the problems of the Two Year College teachers. Not only that, but many senior college colleagues of ours futher confuse the issue by identifying the Two Year College as simply the first two years of college. Such a picture is too simplistic and should immediately serve to disqualify an individual as a reviewer for a Two Year College mathematics project. While I have the greatest respect for mathematical research, as an Algebraist with research results in Ring

Theory, I have found the Two Year College teacher faced with a set of problems that most of our research colleagues would not touch. That is amply evidenced by the lack of applications from entrenched university professors to accept the challenge of making their life's work meaningful to a demanding and skeptical national audience which needs that work.

The National Science Foundation appears to believe that the special needs of Two Year College students will be met through non-specialized projects aimed at traditional college students. It would be a non-trivial exercise to describe today's Two Year College student and differentiate between him and the traditional college student and the needs and wants of each. The Foundation states, "Our projects are attentive to science and mathematics education at the college freshman and sophomore or other levels without special regard to the question of where the courses are taught". The Science Education Directorate's quoted response reveals a disregard for the difference between Two Year Colleges and the first two years of other colleges and indicates a lack of sensitivity and a pressing need to be informed and instructed by this Subcommittee.

On the only currently funded mathematics curriculum project which the Science Education Directorate feels might meet the needs of Two Year College students, they have almost entirely prestige institutional affiliations for the steering committee and the project staff. This information is detailed in appendices of that proposal. That project may eventually involve National Science Foundation funds in excess of one million dollars in the grant area of mathematics teaching (not research). It would appear reasonable that the staff and steering committee of a mathematics teaching grant funded for Two Year College students would have substantial experience with Two Year Colleges and those students who select a Two Year College program and learn from Two Year College mathematics teachers. Although we find M.I.T., Cornell, Columbia, etc, mentioned, not one Two Year College is represented among all the directors and program staff. This was surely known to the Foundation at the time that the initial award of over four hundred thousand dollars was made. Futhermore, a summary of the funded project appearing in a recent issue of the contractor's house organ made absolutely no mention of Two Year Colleges. And yet, the Science Education Directorate offers this project as a response to the question of how they are meeting the needs of Two Year College students.

The American Mathematical Association of Two Year Colleges was suggested in 1974 at a symposium of Two Year College Mathematics teachers in New York City. In 1975 the Association was founded. It was necessary to fill a void which existed between the National Council of Teachers of Mathematics which serves secondary school mathematics teachers and the Mathematical Association of America which serves senior college mathematics professors. In doing so, AMATYC provides a national convention expressly designed to meet the needs of Two Year College mathematics teachers. It is representative organization which reaches into each Two Year College to sample and reflect the professional feelings of the Two Year College mathematics teachers. It provides a unified national voice for Two Year College mathematics teachers on matters of educational priority. It fosters and promotes professional recognition for Two Year College mathematics teachers. It provides a national forum to exchange ideas and promote interest in mathematics and mathematics education. Since its founding, AMATYC has experienced rapid growth and has held two resoundingly successful conventions. Both the Chicago meeting of 1975 and the San Francisco meeting of 1976 echoed the same feelings of concern which took shape as the following unanimous resolution:

> Resolved: In review panels selected to read proposals concerning teaching (as opposed to non-teaching research) at Two Year Colleges, first hand experience in teaching at Two Year Colleges should be regarded as a basic competence on the part of the reviewer.

The token addition of a few Two Year College teachers to the National Science Foundation peer review panels, or the donation of pieces of equipment to Two Year Colleges among others, cannot hide the fact that the Two Year Colleges are deserving of their fair proportionate share of N.S.F. Curriculum Programs, N.S.F. Review Panel participation and other N.S.F. activities from which we have been traditionally excluded.

Earlier I quoted the Science Education Directorate as follows, "Our projects are attentative to science and mathematics education at the college freshman and sophomore or other levels without special regard to the question of where the courses are taught". I feel compelled to remind the Subcommittee that if this is so, the National Science Foundation peer review committees on higher education ought to be constituted in the majority by Two Year College teachers in reflection of the proportion of American college students whom we serve.

Until now, my testimony has been of a rather general nature relating to AMATYC and the Science Education Directorate of the National Science Foundation. My remaining testimony will be directed to five particular areas.

1. The ways in which NSF Funding affects the area surrounding the recipient institute.
2. House document HR 94-930, which stresses greater flexibility in Education Directorate guidelines to enhance the eligibility for funding of a greater number of Two Year Colleges in all areas.
3. A more detailed look into aspects of the peer review process to which I referred previously, in light of S.3202 Testimony in 1976.
4. A typical hypothetical sequence of events that might happen to the faculty of institutions in your respective congressional districts, should they apply for Education Directorate funding without already possessing Education Directorate funding.
5. The need for an expediting agent or Ombudsman, responsible directly and solely to this Subcommittee and its counterpart in the U. S. House of Representatives. An office which shall serve as an effective communications link and arbiter between the Foundation and individuals, institutions and consumer groups in matters over which this committee has jurisdiction. The correlate need for this Subcommittee is to encourage the Education Directorate to establish "Peer Review" panels consisting of true peers.

In funding programs through schools and colleges, the NSF or other Federal agency sets up a mutually beneficial arrangement. From the agency's standpoint, its grant of $5000, $20,000, $100,000 or more offers great leverage. It can bring with it extensive unpaid involvement of the teachers, students and facilities of a recipient institution with a multimillion dollar annual budget.

From the institution's standpoint, there is the "indirect cost" figure. Obtained through negotiation with the U.S. Government, this figure varies from recipient to recipient but usually lies between thirty percent (30%) and seventy percent (70%) of the salaries paid out under each particular funded program. The indirect cost is paid to the institution by the agency, above and beyond the salaries and fringe benefits of the project staff themselves.

The indirect cost figure is arrived at by computing the typical overhead costs at that institution, costs such as space, lighting, heat, telephones, bookkeeping, maintenance and so forth. However, since the institution usually does not actually add on more buildings to house the temporary funded program, the indirect cost also serves another function.

Indirect costs constitute one way in which the United States Government subsidizes the running of educational institutions. By helping to keep that institution afloat and viable, these payments and the grants themselves serve also to bolster the economic well-being of the area in which that school is located. Thus, the indirect cost associated with a strictly research or curriculum project will also benefit proportionately the school and its local community.

The Moudy Report of 1975 pointed out that twenty years ago the National Science Foundation's education efforts were trained on what one might call "upper 5%" students. These "upper 5%" students could usually be found at just those places where the frontiers of science itself were being pushed back. One thinks of the Ivy League schools, Caltech, Chicago, MIT and so forth.

Then, during the 1960's and early 1970"s, both America's educational system and her governmental priorities for education became much more democratic. Colleges were founded and flourished whose clientele was not the traditional student but rather the average taxpayer and his family. These entering students, like most Americans, were not the end product of a college preparatory program. In general they had a bit more experience in the world, less formal education, somewhat higher age, and a more job oriented approach in selecting their courses and even their colleges.

In short, they were <u>different</u> from students at the universities, and they wanted and obtained a college level education in institutions more suited to their learning background and their more mature lifestyle. For instance, an English literature major at MIT might enter college having finished his or her calculus in high school with advanced placement credit. But an employed technician who wanted to advance to a technologist title, might instead choose to take courses at his or her local two year college, which would test that worker's entering skills and might very well start the worker off with regular courses conveying basic arithmetic skills.

In the end, the technologist with the one year certificate or two year terminal degree would turn out to be much more a practicing scientist than the English literature major at MIT. But the technologist would probably shun the prestige institution precisely because its senior professors were averse to teaching basic computational skills and, fortunately for themselves and these students, generally did not have to because their own students tend not to have that particular learning need.

The non-elite student realizes something that we can all keep in mind: A two year college education is not the same thing as the first two years of college. This distinction holds whether a student actively seeks a scientific career or just wants to gain the knowledge necessary to get along better in our technological society. Today the two year colleges enroll more Americans starting their postsecondary education than all other institutions of higher learning combined.

The House of Representatives realized the uniqueness of the two year college approach when on March 18, 1976, it stated that "an increase in funding priority of community and junior colleges is recommended" for science education programs. Perhaps to counterbalance Education Directorate officials' familiarity with prior grantees at other institutions, the House went explicitly on to encourage "greater flexibility in program guidelines to enhance the eligibility of a greater number of two-year colleges." (HR94-930) During the same month, the Director of the National Science Foundation presented this Subcommittee with a series of memoranda, O/D 76-10, 11, 14, which mandated fairness and balance in the peer review process, an act which promised to recognize the new priority of two year college education as stressed by Congress.

Available from the minutes of Subcommittee Hearings on S.3202, the cited memoranda promised ready feedback to proposers "Testimony pages 230, 234": Acquisition of appropriate clarifying information from proposers after transmittal of pertinent portions of reviews (page 34): and review panels both aware of the proposals' social/environmental impact and competently representing "Each of the principapl institutional, educational, regional or other elements of the relevant communities which might be affected by the project", (page 238). To assist NSF Officers in selecting review panels, the memoranda went on to stress such particulars as "concerned public" representation (page 240), female representation (page 241), and the importance of reporting the compensations made for significant biases on the part of reviewers (page 238).

Unfortunately, over the last year since those instructions reached the NSF, the Two Year College mathematics teachers have heard occasional compliments from the Science Education Directorate but seen little substantial changes in policy. The National Science Foundation still has never funded a major mathematics curriculum program geared to the two year college students (who in 1977 constitute the majority of those entering college).

Because of the charge of this subcommittee is the oversight of the National Science Foundation, it seems very appropriate to bring to you some factual data relating to that oversight function. Although the General Accounting office has publicly revealed instances of Science Education Directorate favortism in the past, I believe that this year is the first time any proposal writers have permitted a professional society to cite their NSF case history in support of public testimony before a subcommittee of the United States Senate.

I will refer to two distinct NSF case histories: The "New Statistics", co-sponsored by AMATYC, and the request of NSF funding, to increase circulation and availability, by the MATYC Journal. I have had no direct personal involvement in either of these cases and they both occurred prior to my assuming the presidency of the American Mathematical Association of Two Year Colleges. Let me underscore that no specific action is either requested or expected to be taken by this subcommittee on these cases, and that their details are cited here with the sole purpose of informing you and other readers of this testimony that such things actually have happened.

Since the members of this Subcommittee, the full Human Resources Committee and the United States Senate itself needs the facts readily available in order to have the most effective possible deliberation, I offer to supply documentation to support any statement, although the statements are presented in general hypothetical terms to expedite the reading of them.

For the hearing record of the Subcommittee, I am supplying annotated versions of two editorials from the MATYC Journal in which the editors explain how this Two Year College proposal came to be decided on by non-two year college persons in competition with the proposers. I also supply a one-page summary of a curriculum program "the New Statistics" in which there appears a tabulation of goals. Many of these goals appeared in the original proposal. [1]

1) Goals: 1 (page 9 of 1974 proposal), 2 (page 10), 3 (page 11), 4 (page 8), 6 (page 2), 10 (anticipated on pages 1-11), 11 (page 8), 12 (page 1), 13 (page 4), 14 (page 3), 15 (page 3), 18 (pages 6, 10) and 19 (page 4).

A very basic principle of statistics is the concept of sampling, the realization that you cannot make a silk purse out of a sow's ear, that if a very expensive and time-consuming process results in the collection of wrong or irrelevant data, no amount of fixing up later is going to convert it into complete and properly representative data. The perennial "NSF peer review" problem in the broader terms of statistics is sampling.

This idea of honest and complete sampling is absolutely crucial in the NSF proposal review process, because the rules state that decisions on proposals are to be based on evidence found solely in the written comments of anonymous peer reviewers, plus the specific responses of the proposers to specific questions raised by these reviewers. Possible conflict of interest, as noted in the MATYC Journal editorials, is only one obvious facet of this process. A less obvious facet is that NSF reviewers of a two year college proposal may not even understand its main points.

If you submit a proposal for one or two hundred thousand dollars in computerized instruction, videotaping, and other specialized media processes; and if in two consecutive submissions the Foundation does not select any "peer reviewers" for that proposal who can be identified as having specialized media expertise; then in two consecutive NSF decisions those hundreds of thousands of dollars will be awarded or denied without the benefit of any allowable informed input whatsoever.

If you organize an educational consortium which explicitly includes between ten percent (10%) and fifteen percent (15%) of all the women's colleges in the nation; and if the "peer review" panel not only is devoid of women's college faculty, but does not even contain any women; then the special women's considerations will not really receive competent review even though the review and decision take place during International Women's Year.

If your detailed plans for improving instruction at the elementary and high school level nationwide have the active support of the appropriate professional societies, many key leaders in this field, and educational officers in several states and Canada; but if the "peer review" panels on two consecutive proposal submissions do not contain any ordinary school teachers, school administrators, or parent association representatives; then the review panel is very likely to be quite incompetent on the relevant issues, whether it generously recommends funding the program or not. If performed in accordance with NSF rules, no amount of subsequent analysis of these peer reviews will erase the fact that the data collected is not a representative sample of informed expertise.

Many students enter Two Year Colleges, Women's Colleges, Black Colleges or Hispanic Colleges with a fear of mathematics and without traditional high school training in mathematics or the better-prepared student's fascination with math-for-math's sake. They are qualitatively different from the traditional college preparatory students.

If you propose a complete educational system built around the removal of barriers encountered by most students at two year colleges but by relatively few students at select colleges and universities; and if your review panel of nine "peer reviewers" contains only one true peer possessing substantial teaching experience with two year college students; then the vast majority of these reviewers will not possess sufficient firsthand experience with students in the target population even to understand clearly why they personally each approve or disapprove of the basic thrust of your program. I suspect that this lack of understanding was also at work in the situation to which the MATYC Journal editorials refer.

Finally, if you propose to improve the teaching of a mathematical subject which is as well-defined as elementary algebra and at an elementary level equally inappropriate for receiving complicated major influxes of "state of the art"; and if most of your "peer reviewers" specialize not in teaching but rather in theoretical research or in "state of the art" applications; then you have the worst problem of all. The problem of incompetence masquerading as competence.

This misplaced expertise may be the paradigm of Education Directorate review panels. In forming its previous review panels, the Education Directorate has violated the most basic principle of statistics, the need to sample from the population of interest. A lopsided "peer review" panel like the one described will continue to give you misleading data even if it is doubled, tripled or quadrupled in size.

A basic misunderstanding of this principle of representative sampling may also explain why NSF educational programs for average students at ordinary institutions are so often written and edited at think tanks tied to prestige institutions and then field tested on very well prepared students.

This penchant for reviewers from prestige institutions, prestige grantees and prestige tryouts may be acceptable in other areas which the National Science Foundation serves. But it is extremely bad scientific practice when applied in exactly the same way through the Science Education Directorate.

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It is possible that science education might benefit from a fresh and constructive start under the aegis of an agency or agencies which have greater expertise and a greater awareness of the educational needs of the majority of the American people. This separation could be of benefit to the national interest not only in terms of education, but also in removing the key distraction from NSF's primary mission of scientific research and development.

However, even if every member of this Subcommittee were to agree that removing the Education Directorate would strengthen the rest of the National Science Foundation, scheduling considerations might preclude such action on the FY 1978 budget. In more immediate terms, this Subcommittee could help to correct the Peer Reviewer Problem by issuing a clear statement encouraging better representation beginning now. Other violations of fair procedure would call for an Ombudsman within the National Science Foundation responsible directly and solely to this Subcommittee and its counterpart in the U. S. House of Representatives, an office which shall serve as an effective communications link and arbiter between the Foundation and individuals, institutions and consumer groups in matters over which this Subcommittee has jurisdiction.

Since an NSF Ombudsman could also deal with non-educational units of the Foundation, I want to emphasize that my testimony concerns only the Education Directorate, during the period from 1972 to 1977. To the best of my knowledge, the strictly scientific research activities of the Foundation, under Director H. Guyford Stever and his successor, Acting Director Richard

C. Atkinson, have been carried out with dispatch and excellence.

Analogies between educational R&D and scientific R&D are of course possible. But the changing priorities of education are socially determined, whereas scientific R&D is influenced greatly by the availability of natural resources, the defense needs of this and other nations, and other external considerations. Energy research appears to be with us permanently, whereas a particular educational priority can be phased out in a year or two.

For two and one half years a single program idea has been shuttled back and forth inside the NSF Science Education Directorate. Perhaps the timeline given below typifies the usual treatment received by new applicants to NSF's Education Directorate.

To focus on new applicants, rather than repeat awardees, is important for two reasons. From a scientific standpoint, truly innovative ideas sometime issue from persons not already receiving NSF funds. From a standpoint of fairness, I believe that it was the "new faces" nature of the application discussed here which put it in a two and one half year holding pattern, while similar proposals by familiar NSF friends were approved in periods ranging from 20 days to two months.

Quoting from the Science Education Directorate:

"The purpose of the preliminary proposal is to enable the staff... to provide whatever feedback is necessary to ensure that a formal proposal will be prepared in the best possible way....
There are no fixed deadlines for the submission of proposals.
The staff will make every effort to respond to preliminary proposals within six weeks of receipt."

Eight and one half weeks after a Two Year College applicant submitted a preliminary proposal, the Education Directorate wrote to say that they were not going to respond to the preliminary proposal.

The Directorate stated in this and a follow-up letter that the decision of whether or not to fund the program was going to be delegated to a competing applicant, a group serving a totally different student clientele, which the Directorate described as a "Fraternity" and to which it gave funding for meetings and a report.

> "If (your ideas) receive support... and this approach is recommended as one to which we should give high priority, then we would be in a position to encourage you to submit a formal proposal. As I stated in my earlier letter, your prospectus is being set aside for the time being."

There were clear issues here of transference of authority and likely conflict of interest. Moreover, if you have spent your time and effort in developing a system of good ideas which is unique and might be fundable, it is irksome to be told that you must share these ideas with a competitor before the funding agency has even consented to honor the guidelines and respond to your proposal.

But if NSF sends you two letters saying you must submit your ideas to your competitor in order to remain in contention for funding; and if you want to remain in contention for funding, you submit.

Over the next year, the Two Year College applicants donated a lot of their free time to make their competitor's project more of a success. After a time-consuming summer meeting, and as the revised comments to which they must respond became five weeks overdue, the competing grantee refused for weeks to answer the letters asking what the deadlines were. They sought help from the National Science Foundation; the Foundation wrote back, stating that, since the competitor's grant lacked

> "specific provisions for handling correspondence, we are not in a position to mandate any standards for timely response to communications."

This exchange took place shortly after the competitor and NSF had been on the telephone concerning the competitor's proposed new, larger grant.

The Science Education Directorate agreed to respond to an amended form of the preliminary proposal.

A month later, the Education Directorate sent back a reply which was admittedly "not exhaustive", appeared to have mis-read key passages, and in no way resembled "whatever feedback is necessary to ensure that a formal proposal will be prepared in the best possible way." Since they had waited nine months for this feedback and already disclosed their unique ideas, the applicants called the Directorate to try to get the promised "feedback necessary."

A week later, the Science Education Directorate representative wrote himself a note concerning this request for feedback:

> "The less we tell [[them]] about specific things that should go into a proposal the better."

After purchasing copies of old grant applications from NSF to see what should go into a proposal, the Two Year College applicants noticed that most of the major ones were sponsored by an appropriate professional society. They felt that the American Mathematical Association of Two Year Colleges (AMATYC) was the appropriate professional society to sponsor their consortium of over one hundred colleges and schools, in forty-four states.

When approached, the governing board of the American Mathematical Association of Two Year Colleges voted unanimously to co-sponsor this project.

The two year college applicant put forth the whole consortium program before a room of 100 professors at the October 1975 AMATYC meeting, and sent a final letter of transmittal to the Science Education Directorate:

> "We have taken care to ensure a wide geographical representation, with specific inclusion of audiences traditionally thought to be poor risks in mathematics education; e.g., women, minorities, and adults who have been out of school for some time."

The two year college applicant sent NSF an extensive packet concerning the central staff's track record in administering programs.

The packet showed that among the six main directors there was more than one hundred million dollars of track record in running and evaluating educational programs, an amount larger than the Educational Directorate annual budget.

After some time, a recommendation for declination (NSF form 9) was written, centered about lack of track record.

Clearly, appropriate clarifying information supplied by the proposers was not used in the manner described on page 34 of the March 1, 1976 hearings transcript of this Subcommittee.

By contrast, a proposal from a current Education Directorate grantee strongly resembling the two year college applicant's Goals: 16 (their A), 1 (their B), 18 (their C) and 10 (their D) was

1. received by the Education Directorate on or about April 2, 1976.
2. reviewed by the Directorate's reviewers on or about April 22, 1976.
3. confirmed by a Directorate site visit on April 26, 1976.

4. announced formally on June 30, 1976, the day before the program starting date and the last day of the grantee's prior NSF Education Directorate award.

Thus, the prestige college insider obtains a tentative decision on a non-two-year- college program in about three weeks, whereas a nation-wide consortium of others waits for two and one half years with no final decision.

In view of evidence presented here, the American Mathematical Association of Two Year Colleges suggest that you adopt a resolution similar to the following: This Subcommittee encourages the National Science Foundation to establish a policy of having people experienced in Two Year Colleges constitute the majority in Review Panels for proposals from Two Year Colleges, and to inform the Presidents and Heads of Science Department at Two Year Colleges that this policy is now in effect.

A second step is the establishment of an Ombudsman within the National Science Foundation responsible directly and solely to this Subcommittee and its counterpart in the United States House of Representatives.

In conclusion, I recognize that a large part of this testimony speaks to difficulties encountered by two separate groups of two year college teachers. However, the American Mathematical Association of Two Year Colleges prefers to display an affirmative posture. It is my intention and the consensus of all members of the Association to whom I have spoken to provide advice, support, professional expertise and assistance to any and all agencies of the United States Government which provide financial or other support for education at the two year college or other levels. It is our desire to establish an atmosphere of cooperation and confidence and serve as a communications link between the students and mathematics teachers whom we serve and the govermental agencies and Congress who serve the same people.

On behalf of the membership of AMATYC, I wish to offer my graditude to the Senate Subcommittee on the National Science Foundation for the opportunity to testify on these matters relating to the National Science Foundation and offer the services of AMATYC on any future testimony the Committee may desire from Two Year Colleges.

Respectfully,

Dr. Joseph E. Cicero
President - AMATYC

Enclosures

MATYC Journal, Winter 1976, Vol. 10, No 1.

EDITORIAL

NSF FUNDING (CONTINUED)

Since early 1972, The MATYC Journal has attempted to receive financial support from the National Science Foundation in order to cover its ever increasing circulation demands. Two proposals have been submitted and, as our readers are aware, both have been unfavorably received. We believe that this is principally due to the selection process by which *university* people served as the primary referees of two-year college projects (see Fall 1974, Vol. 8, No. 3 editorial).

Recently, the National Science Board (NSB), the national policy-making body for the NSF, has adopted a resolution designed, "to assure that the Peer Review process helps the effective evaluation of proposals with the fairest possible treatment of each individual and the broadest possible participation of scientists and others." We wholeheartedly endorse this proposal and feel that it can only allow a greater "share of the pie" for TYC mathematics educators. We lament the fact that The MATYC Journal was unfortunately not able to come under this resolution during the years 1972-1973 when its proposal for funding was first initiated.

MATYC JOURNAL, FALL 1972, Vol 6, No. 3

COMMUNICATIONS

"There are perhaps few phenomena of man's life which are of greater concern to more of his number than communication."[1]

The concept of communications is very important to the teacher since the essence of his profession as a teacher is to communicate. To be a good teacher, he must communicate well on several levels. He must communicate with his students, and must allow the students to communicate with him as a teacher. They must understand each other, and there must be a free flow of information between them. As an educator, the teacher must communicate with the administration of the college and make provisions for the administration to communicate back so that there can be communication and understanding between them. Further, as teachers and educators, faculties at two-year colleges must communicate with each other.

As mathematics teachers, we have many problems unique to the two-year college movement. These problems, many of which have been defined only in the last year or two, have defied solutions for many years by many experts in the field. Perhaps some of these problems have been solved somewhere in the United States; or failing attempts at solving a particular problem may have been noted. It is our responsibility as a journal to communicate so that teacher successes may be passed on and avoidance of the repetition of failures may be realized.

Communication is the main theme of THE MATYC JOURNAL. Communication is our purpose! We hope this JOURNAL is and will continue to be a means of communicating from teacher to teacher so that we can isolate, identify, and solve some of the many problems that face the two-year college mathematics teacher. The staff of THE MATYC JOURNAL now consists of over 30 two-year college faculty who are involved on a daily basis with problems confronting the two-year college teacher. Included among the staff are the regional editors, who now cover 15 states. Eventually all states will be represented by regional editors. This unique feature of THE MATYC JOURNAL enables our publication to be responsive to the needs of all of the various provincial interests among TYC's throughout the country.

Over the past years THE MATYC JOURNAL has grown into a prestigious publication with a circulation of over 2,200. Subscribers come from each of the fifty states. The future is bright! Communication is the key, and with THE MATYC JOURNAL all TYC math faculty have the key at their disposal.

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[1] Thayler, Lee, *Communication Theory and Research*, Charles C. Thomas, Pub., Springfield, Illinois, 1967.

Editors-in-Chief George Miller (*left*) and Frank Avenoso (*right*) presenting a letter of appreciation to Congressman John Wydler, June, 1972.

POLITICAL IMPACT AND THE GROWING TWO-YEAR COLLEGE MOVEMENT

THE MATYC JOURNAL has applied to the National Science Foundation for funding to meet the needs of the growing national movement in mathematics education at the two-year college level. It was through this project that the editors first became aware of the positive sentiments of certain political leaders towards the two-year college movement. In particular, through correspondence with The National Science Foundation and THE MATYC JOURNAL, Senator James L. Buckley and Congressman John W. Wydler of New York, have indicated a willingness to lend their support to the proposal. We commend the efforts of both of these legislators.

In another related area THE MATYC JOURNAL has witnessed the most impressive efforts of state Assemblyman Stanley Harwood (Levittown, New York) to defeat proposed legislation in the state of New York which was anti-educational in nature. In particular, bills dealing with sabbatical leave and tenure were brought to defeat through the efforts of political leaders such as Assemblyman Harwood.

The above three office-holders are but a few of the many prominent politicans in this country, through whose efforts education has continued to grow and prosper. The Editors-in-Chief of THE MATYC JOURNAL would like to extend an invitation to all of our readers to bring to our attention those legislators who have fought in their areas for issues that are important to education in general and to the two-year college movement in particular. We feel that the editorial column should serve as a forum for citing those politicians who have befriended the education movement in this country.

MATYC JOURNAL, FALL 1974, Vol 8, No. 3

EDITORIAL

But there is no need!

In early 1972 THE MATYC JOURNAL staff began preparation of a funding proposal to be submitted to The National Science Foundation (NSF). As a national publication for just over a year, it had a need for funds to greatly increase circulation, number of issues, number of pages, scope, etc.

After an initial proposal was drawn up, Dr. Avenoso and Prof. Miller traveled to Washington, D.C. to meet with Congressman John Wydler (Committee on NSF funding), the staff of Senator James Buckley of New York, the head of the NSF Science information services, and the NSF Program Director for Publications. Ideas and suggestions concerning the proposal were solicited.

Quite an intense conversation ensued with the directors at NSF, concerning the methods that would be used to evaluate the proposal. We expressed our anxiety that the proposal might be evaluated primarily by four-year college and university personnel who might not understand the TYC movement and the audience of our publication. We were assured, several times, that we need not worry, that they "knew their business and would see that it (the proposal) was fairly evaluated." We were still not satisfied and pressed further. "Could you tell us, after the fact, who had evaluated our proposal?" -- "No." -- "Could you tell us, not the names, but the educational affiliation of those who did the evaluation?" -- "No." -- "The percent of TYC evaluators? -- "No!"

Several months later, we submitted twenty copies of a ten-part funding proposal containing history, present status, immediate and long range goals, innovative aspects, financial considerations, staff résumés, operational structures, 30 letters of endorsement, legal structure, and past issues of *The Journal*.

We received a letter dated September 22, 1972, denying our request. We called and asked for specific reasons. At first we were refused. Finally a letter, alluding to the reasons for the NSF refusal, dated October 2, 1972, specifically cited the following four considerations:

1. THE NEED FOR THE PROPOSED JOURNAL.
2. THE JOURNAL'S PROBABLE CONTRIBUTION TO SCIENCE AND EDUCATION.
3. THE QUALIFICATIONS OF THE PERSONNEL INVOLVED.
4. THE PROPOSED BUDGET.

We wrote and called to question the validity of the reasons given. For example, clearly the need had been demonstrated since the publication was already self-supporting on its own merits. We questioned what kind of qualifications did they have in mind?

Shortly thereafter, we received the following letter from a TYC teacher in California.

"Dear Sirs:

"I just reviewed your publication (favorably) for a local U.C. professor who had been asked by NSF to do the same. He felt that I would be more competent to make a judgment (I do not know *why* NSF is sending copies of your funding proposal to *university* professors). In any event, it is favorable and will be in his name.

"The only criticisms I made were of the editorials in Vol. 6, No. 1, which seemed to be only indirectly related to mathematics or mathematics education. I praised highly the other innovative features.

"My five dollars is included for a subscription. I would like to have copies of the back issues if available. Thank you."

The following month we received a letter from Victor Klee (then president of The Mathematical Association of America) saying that, "The MAA has been increasingly concerned, in the past few years, with the mathematical interests of the two-year colleges." He also proposed a merger of the publication efforts of THE MATYC JOURNAL and *The Two-Year College Math Journal* (which was then being published by the Prindle, Weber & Schmidt Publishing Company and sponsored by the MAA).

We have been told by an official of the MAA that, "The MAA is often asked to provide evaluators for proposals dealing with college-level mathematics." If the MAA were involved in the evaluation of our proposal (we were subsequently told they were) and at the same time were considering entering into merger negotiations with us, then it would appear that the last thing they would want is for us to be funded by NSF and become stronger. Thus, we suspected a conflict of interests on the part of the MAA as it concerned evaluation of our proposal.

This past fall (1973) we submitted a second funding proposal. On April 26, 1974, we met with leaders of the MAA (President, executive director, second vice-president, chairman publications committee, chairman two-year college committee, and others) to discuss, for the second time, a possible merger of THE MATYC JOURNAL and *The Two-Year College Math Journal*. We turned down their proposal of merger, for the present. The following week we received an NSF letter (dated May 3, 1974), rejecting our proposal.

We feel that the NSF does not presently have a fair system of evaluation of two-year college related proposals (ours or others). We feel that they rely too heavily on the MAA for their opinions. We suggest that, in the future, the NSF could solicit more expert advice on TYC matters by asking the leadership of the new *National Mathematics Association of Two-Year College Educators*, which was born this past spring.

"New Statistics"

(A.M.A.T.Y.C.)

RESULTS: Tabulation of Goals

Since 1974 we have been working to achieve four broad goals through the funding of this program:

A. To help teachers and other Americans to feel more at home with statistics.
(A profession-wide goal)

B. To get more Americans actively involved in science education R&D.
(An institutional goal)

C. To study, and improve, the learning of statistics.
(A course content goal)

D. To produce needed aids to learning statistics.
(A materials output goal)

These four broad goals are to be achieved through:

GOAL

PROFESSION-WIDE GOALS:

1. To re-establish and make permanent an intercommunication network among statistics teachers which makes them active participants in the development of statistics pedagogy (accomplished through Teaching Statistics, increasingly successful in pilot issues from April, 1975, to February, 1976).

2. To produce a readable and comprehensive instructor's manual in elementary statistics, equally usable as a daily guide to experienced teachers or as a textbook in methods courses for potential teachers at the elementary, secondary and college level.

3. To increase the number and quality of conference presentations and scholarly articles on innovative statistics teaching, by both primary and "ripple" effects.

4. To increase and make more favorable) news and feature articles which concern computational scientific work, written by the regular staff of student newspapers, regular newspapers, popular magazines, and broadcast media.

5. To increase the amount of statistics taught in mathematics survey courses at all levels (grade 5 to college).

6. To increase the number of students registering in courses substantially equivalent to the standard one semester noncalculus statistics course.

INSTITUTIONAL GOALS:

7. To provide a well-known precedent which will encourage proposal submissions to NSF (Science Education Development & Research) from Community College mathematics teachers now without an available precedent.

8. To provide a well-known in-State precedent to encourage proposal submissions to NSF (Science Education Development & Research) from colleges in fifteen largely rural States now without an available precedent.

9. To hold three annual conferences (leading to summary reports) of an established Advisory Board on innovative statistics teaching, a voluntary effort of over sixty leading statistics practitioners, mathematics educators, professional society heads, and other leaders of interwoven segments of American and Canadian Education.

10. To preserve and expand a smoothly functioning user producer run Consortium having documented active involvement of at least 110 institutions in 44 States prior to the January, 1976, submission.

11. To establish a temporary administrative/materials Center, coordinating all program activities, to be dismantled after the program's goals are achieved and its dissemination functions have been transferred to publishers and other regular channels of materials distribution.

12. To acquaint Black, Hispanic, Native American, Portugese-American and women students with local employment opportunities made available by the statistics course in which they are enrolled.

COURSE CONTENT GOALS:

13. To find out what topics are taught in the standard non-calculus statistics course in various settings.

14. To increase the number of topics taught in the typical non-calculus statistics course in various settings; to increase student mathematical judgment.

15. To isolate a sequence or sequences of standard statistics topics which can be mastered more rapidly than the usual sequence and by mathematically less sophisticated students.
(I.e., to make statistical education more "equal" by reducing test score correlations with sex, income, ethnicity, etc.)
a. Using regular lectures and texts.
b. Using Keller or lab plans.
c. Using modules described below.
d. Using computerized instruction

MATERIALS OUTPUT GOALS:

16. To produce sets of applications exercises in statistics written by consultants from the world of work (200), who represent the major sources of employment for students in consortium schools. In some fields (e.g., nursing) complete exercise books will be offered while in others, problems will reach the public domain.

17. To make available high quality mathematics instructional materials in the Spanish language. (Also braille and French for one non-redundant set of modules.)

18. To produce a complete, three-deep-redundant set of modular written lessons in elementary statistics, which are
a. Written at the college level by those teaching less-skilled.
b. Statistically correct.

(Statistical integrity Advisory Board members, denoted by "2C" code, specify use and staffing of complete Adm.Asst.line.)

c. Edited to the sixth grade reading level.
d. Professionally illustrated.
e. Validated each on 300 of 10,000 students in consortium courses.
f. Field tested each on 1000 of 15,000 pre-college students in affiliated school systems.
g. Acceptable to representative groups of parents.

h. Sold individually and in bound form through commercial publishers (with standard royalties paid to NSF or used to subsidize some Goals past the period for which funding is requested.)

19. (From 18) To produce corresponding
a. Overhead transparencies to be distributed commercially or through the Committee on Audiovisual Instruction of the American Statistical Association.
b. Slides, audiocassettes, filmstrips and films to be distributed commercially.
c. Color and b/w videotapes
i. to be distributed by Great Plains National Television, New York State and other such repositories.
ii. to be upgraded electronically and shown on network, local, or cable television.

20. (From 18) To produce corresponding computer-aided interactive course in two of: COURSEWRITER, A P L, TUTOR, AND BASIC.

21. (From 18) To produce a syndicated feature column for newspapers (and appropriate magazines such as Ms. and Rolling Stone), which teaches statistics and enables the reader to earn course credit from institutions in at least four distinct regions of U.S.

22. (From 18) To produce the instructional booklet necessary to establish a Girl Scout and Boy Scout Merit Badge in Statistics.

23. (From 10) To produce two trial issues of Stat-Biz comic book (quantity printings) and make the property available to commercial publishers.

[From the Atlanta Constitution, Aug. 28, 1975]

STATS COURSE BELIEVED 30 PERCENT BETTER TO BE TAUGHT

(By Chuck Bell)

An innovative course in statistics that is said to be 30–40 per cent more effective than traditional statistics teaching techniques will be taught at Spelman College this fall, according to one of the professors who developed the course.

Richard G. Lefkon, who teaches statistics at the Staten Island Community College of the City University of New York (CUNY), said the predominantly black women's college is the first school in the Atlanta area to adopt the new method.

Lefkon, who was in Atlanta to attend the American Statistical Association meeting at the Hyatt Regency Atlanta this week, said the new course almost completely reverses the traditional approach to teaching statistics.

"Most statistics textbooks start out teaching standard deviations in the first chapter," Lefkon said, "and save the chi-square test for the last chapter. But standard deviation is a very difficult thing to learn. The chi-square test is the simplest thing in statistics. I can teach anybody how to do it in 30 seconds."

Lefkon said he didn't know much about statistics until he was assigned to teach a statistics course a few years ago. He feels the fact that he was not trained as a statistician enabled him to bring a fresh approach to the teaching of statistics.

The statistics course Lefkon described is a product of the Arithmetical Statistics Project, of which Lefkon is one of the directors.

Using a thin paperback textbook they wrote themselves and several audiovisual aids, the professors of the Arithmetical Statistics Project began teaching their simplified statistics course to students at Staten Island Community College in 1974. Since then, the course has been taught to students ranging from sixth-graders to graduate degree candidates with impressive results.

A New York teachers' organization reported that students taught by the Arithmetical Statistics Project learned 30–40 per cent more about statistics than students taught by traditional methods.

The main goal of the Arithmetical Statistics Project is to avoid calculus in the teaching of statistics.

"Calculus frightens people away, especially students who aren't majoring in science or mathematics," Lefkon said. "When a student is introduced in the first lesson to standard deviation by means of a formula containing 11 unfamiliar symbols, his immediate reaction is to drop the course."

In the course developed by Lefkon and his colleagues, however, the first important statistical concept the students learn is the chi-square test, a much simpler concept than standard deviation.

Lefkon said his reversal of the usual order of teaching statistics is largely a result of his habit of reading books from the back to the front.

"Since I started at the back of the book," he said, "the chi-square test was the first thing I saw. Later, I got to the standard deviation and realized that it's a more difficult concept than chi-square."

Lefkon said several statistics instructors have told him they don't teach the chi-square test in their classes because "it's too advanced."

"The only reason they think it's advanced," he said, "is because it's at the back of the book."

A simple chi-square test can be used to determine if a die is loaded.

When a die is rolled, there is a one-sixth chance that a particular number, a three, for example, will be rolled. This does not necessarily mean that one of every six rolls will produce a three but it does mean that, over a long series of rolls, the total number of threes should be close to one-sixth of the total number of rolls.

If the die is rolled 60 times and a three appears 12 times, is the die loaded?

Since 10 threes were expected and 12 actually resulted, the actual number exceeded the expected number by two. The difference is 20 per cent of the expected number.

If two is multiplied by 20 per cent, the result is 0.4. This number is the chi-square. A quick glance at a chi-square distribution table shows that the probability of a chi-square of 0.4 resulting by chance in a series of die rolls is better than 99 per cent. In other words, the die is honest.

But if the die is rolled 6,000 times and a three comes up 1,200 times, the situation is different. Atlhough the actual number of threes is still only 20 per cent more than the expected number, there are 200 more threes than expected, resulting in a chi-square of 40.

According to the chi-square table, the probability of that high a chi-square resulting by change in less than one one-hundredth of one per cent. The die is definitely loaded.

Although most statistics teachers are reluctant to change, Lefkon said, he expects the arithmetical statistics method to gain widespread acceptability eventually, especially in courses for non-science students.

The reason for this belief is the fact that the arithmetical statistics course overcomes the basic difficulty of the traditional statistics course, which is that many of the students who enter the course do not have a firm enough grasp of advanced algebra and calculus. Prior mathematics experience is not critical in the new course, Lefkon said.

Apparent agreement came from a professor at a midwestern university who said, in endorsing Lefkon's method, "It's about time that we meet the students where they are rather than where we think they should be."

[From the Atlanta Journal, Aug. 27, 1975]

STATISTICIANS PLAY NUMBERS GAME

(By Ron Taylor)

"We use the number alpha," the man is explaining. "What's an alpha? I don't know. I guess we are supposed to call to God and say, 'Can I have alpha?' "

The audience listens attentively. Only standing room is left in the hotel meeting room. Some listeners sit cross-legged on the floor. They applaud occasionally.

"Does the same p-value mean the same thing in different situations?" another speaker inquires, answering himself, "Not when we know what it means."

They are talking statistics, and the audience seems to understand, though one fellow in the back dozes unappreciatively.

The occasion is the 135th annual meeting of the American Statistical Association (ASA) that has brought some 1,800 statisticians, economists, sociologists, biologists and physical scientists here this week to learn the latest in the American numbers game.

Besides alpha and p-values, the speakers talk about "little p-obs"——p observances, one speaker explains to the ignorant——significance tests and nesting properties, decry the degree of adhocery and debate whether to accept or reject .05 for something.

"The study of statistics is a stupid profession," one statistics professional told his audience, "because it consists of people who insist on being wrong 5 per cent of the time," relating that somehow to the .05 debate.

"We do have a problem of communicating to the nonscientific community," one ASA publicist readily admits.

But the scientific community apparently understands well enough to want to know still more about the statistics that determine what Americans watch on television, what they pay for their gasoline, what they spend on welfare programs and even what people are likely to die of.

The meeting here will tackle a number of important and volatile issues, from the confidentiality of statistical systems to the long-range outlook for food supplies.

Simultaneously, scientists will be looking at ways to refine the statistical processes, and that is where the p-values and alphas come in.

Among the more intriguing titles of papers to be delivered:

"On the Distribution of the rth Largest Discrete Ordered Variate and a Test Based on the Largest One."

"Return Migration to Puerto Rico."

"Modelling the Cyclical Course of Social Sciences Phenomena by Nomography: The Case of Affective Diseases."

"Confidence Regions for Robust Regression Estimates."

"Identifying an Unknown Member of a Large Population."

"Domestic Conflict and the Overflow of Governments: An Exponential Decay Model Applied to Latin America, 1946–1966."

Statisticians are human, nonetheless.

"They are inveterate punners," says an ASA publicist.

And a certain amount of wit did twist through the dialectic at the opening session Monday.

Quipped one punster, "One is not inclined to have confidence in confidence intervals."

Some speakers were acerbic. "Anyone who doesn't use preliminary tests is an idiot," said one.

And others seemed to have stumbled to their wit. The reason some statisticians are "nervous over adhocery," declared one eloquent professor, is that "we often are too highly artistic in our exploratory data analysis."

While those with elaborate papers to read held the stage, others with pet projects to relate had them posted in a basement exhibition hall, waiting to show off their knowledge.

The fellow seeming to get the most attention was one who had labeled his display with large Old English lettering: "Progressive Huberizing."

The scientists with posted graphs and analyses shared exhibit space with statistics firms and government agencies hustling books and pamphlets.

A sign at the National Center for Health Statistics display apologized, "Sorry, Exhibit Lost."

What it was, explained one of the exhibit workers, was a multi-colored cylinder depicting "the rainbow of books" the agency offers.

"We had the only exhibit going through the Panama Canal," the worker said in way of explanation. "You know it goes into one lock, then another, then another."

Where was it being delivered from, she was asked.

"Washington, D.C."

That's not true confessed her coworker.

Statistically speaking, the odds were 50–50 the exhibit would make it from Washington, or wherever, through the Panama Canal and into Atlanta sometime before the convention ended.

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Comments and Remarks on the Testimony presented to the Senate Special Sub-committee on the National Science Foundation at the FY 1978 Authorization Hearing on March 3, 1977.

Submitted to: Honorable Edward M. Kennedy
United States Senate
Room 431, Russell Building
Washington, D.C. 20510

Submitted by: Dr. Joseph E. Cicero
President - AMATYC
Clayton Junior College
Morrow, Georgia 30260

Attention: Ms. Ann Strauss

AMATYC

American Mathematical Association of Two Year Colleges

Chairman Kennedy and members of the Senate Special Subcommittee on the National Science Foundation, I appreciate your kind invitation to offer these comments alongside the testimony of my four distinguished colleagues.

I am Dr. Joseph E. Cicero, President of the American Mathematical Association of Two Year Colleges. As you will note from the formal statement I submitted earlier, there is a difference between AMATYC and the other major professional associations represented at this hearing. The American Mathematical Association of Two Year Colleges bases its membership on teachers, rather than on administrators or industrial scientists, and as the President of AMATYC, I receive reports on how science education is progressing on our educational frontier: the classroom. Fifty five percent (55%) of American college students who begin college this year, will do so at two year colleges, and almost every one of them will take a mathematics course from one of the professors whom AMATYC represents. Thus, it follows that, instructors like myself will soon be teaching mathematics to a majority of all Americans now in the process of being admitted to college.

The membership of AMATYC is in agreement with much of the testimony you have already heard. In this, our first year of testimony before the Subcommittee, AMATYC is proud to co-sponsor with AACJC a recommendation that this Subcommittee encourage the National Science Foundation to establish a policy of having people experienced in the two year colleges constitute the majority in review panels for proposals from two year colleges, and to inform the presidents and heads of science departments at two year colleges that this policy is now in effect.

This joint recommendation originated from the following resolution, which was passed unanimously by the membership of AMATYC at our San Francisco meeting last October:

. "Resolved: In review panels selected to read proposals concerning teaching (as opposed to non-teaching research) at two year colleges, first hand experience in teaching at two year colleges should be regarded as a basic competence on the part of the reviewer."

For some time now it has been clear to the membership of AMATYC that the rationale behind innovative two year college science education proposals would have a difficult time being understood and accepted by our counterparts at the Four Year Colleges and Universities. Ms. Singleton of AACJC has described some of the differences for you, as well as the spiral effect of NSF's high track record of rejecting two year college proposals. At one point AMATYC even sponsored a project with the explicit goal, "To provide a well-known precedent which will encourage proposal submissions to NSF . . . from Community College mathematics teachers now without an available precedent," and with a follow-up measurement of counting the rise in applications to NSF by two year colleges. We still feel that the use of well-publicized precedents will elicit many times more innovative two year college proposals than will increased travel perquisites for NSF staff who may lack substantial experience teaching in two year colleges.

The basic outlook of the traditional NSF proposal reviewers from senior institutions is not quite as favorable as Dr. Williams' characterization that "you have to be more creative" if applying to NSF from a less well-known institution. In one NSF peer review I have seen, a distinguished writing team assembled for a two year college proposal, centered about some thirty published textbook authors in that particular field, was dismissed by the anonymous NSF reviewer as follows: "I am reminded of the old bromide about chimps at work typing at random on typewriters."

In my statement submitted for the record, I quoted the Foundation's published position of treating its education proposals "without special regard to the question of where the courses are taught." The membership of AMATYC feels that this policy must be reversed, but we disagree with one of the possible solutions presented by Ms. Singleton of AACJC. We feel that the diversion of two year college NSF funds for "consultant grants," in which someone from a university comes to show the two year college teacher how to teach is, antithetical to the independence and community based innovation which have been the key to the rapid and continuing growth of the two year college movement.

We at the Two Year Colleges do not need vast influxes of university faculty descending upon us to tell us how to teach the very students against whom many universities have closed the curtain. In our teaching fields our intellectual credentials are at least the equal of those of university counterparts, whose main instructional experience may sometimes consist of the overseeing of graduate teaching assistants.

We in the Two Year Colleges have the expertise to manage our own NSF science instrucation programs. What we lack is a genuine acceptance by NSF of our closeness to the community and our willingness to communicate with our students in terms which the students understand.

Senator Kennedy, you asked the others testifying before you why neither Congress nor the American people are willing to accept the idea of expanded financial support for science education. I am afraid that part of the cause originates with the National Science Foundation Education Directorate and with the elitist approach the Directorate encourages and appears to make mandatory.

Two years ago last August, two proniment Atlanta newspapers carried feature stories about a convention of statisticians and statistics teachers meeting in Atlanta. I submit photocopies of these two articles for inclusion in the transcript, at this point.

The first story, in the Atlanta Journal, was highly unfavorable as you can see. I do not believe that this article advanced the cause of additional support for science education funding among the American people. Rather, I surmise at this time that many of those who were described in this article, far from working to reach out into the community, may actually have made it a point to be abstruse and were actually quite proud of this unfavorable writeup.

I suggest that having an unfavorable press was and is considered a badge of merit and true intellectual worth by many of the appointed with whom the Education Directorate deals.

I now ask you to contrast this Atlanta Journal article with an extremely favorable article which appeared in the Atlanta Constitution shortly thereafter.

The two year college professor being interviewed in the Atlanta Constitution article did his outreach job so well that the reporter spent the second half of the story conveying to his regular readers a mathematical concept which he had just learned.

Shortly after the favorable Atlanta Constitution article appeared, a presumably typical NSF proposal reviewer telephoned his own NSF administrator, hinted that a favorable news item must necessarily spring from some lack of professional ethics, and then obtained tacit approval from NSF to pursue an "ethics" investigation of the successful project, among large numbers of potential NSF peer reviewers of that particular project.

From documents supplied to me by AMATYC members and similarly available to you, I can assure you that this NSF reaction to the free dissemination of information is not unique. In another incident cited in my formal testimony, an NSF officer wrote himself a note stating that "the less we tell" (a two year college applicant) "about specific things that should go into a proposal the better."

In the third documented incident, a project director at a Two Year College wrote NSF that he was specifying his assistant at a second college to act on his behalf, as his agent, to obtain miscellaneous information under the provisions of the Freedom of Information Act. But when the assistant wrote to NSF for the information, NSF instead sent a letter to this assistant's college president, apparently hinting at some undesirable consequence for the second college unless its president "take any steps necessary to prevent" such requests for information.

Because of documented incidents such as these the American Mathematical Association of Two Year Colleges has reservations about NSF's properly executing or interpreting a needs assessment of science education at the two year college level.

A needs assessment was conducted outside of NSF last year for a particular area of science education, and the data and summary submitted to the Foundation.

In accordance with the recommendations of the Science Curriculum Review Team, presented to this Subcommittee on March 1, 1976, by its Chairman, NSF Assistant Director Robert E. Hughes, a continuing program to assess priorities and guide two year college level curriculum development activities was established. This assessment program included, as recommended, representatives with professional experience in education, curricular development, and in all related disciplinary fields of interest. It included participation by school administrators, teachers and the interested public. (viz. S.3202 hearings, page 245)

This needs assessment concerning an area of mathematics education at the two year college level concluded that all three requirements (ibid., page 201) specified by NSF Assistant Director Harvey A. Averch had been satisfied: There was a low and insufficient rate of technological progress; there were institutional barriers to spontaneous R&D; and there was a special public value attached to better dissemination of the body of knowledge involved.

The recommendations ensuing from the needs assessment received the active support of a majority of women Representatives, of most Black members of the House and Senate, of most Hispanic members of the House and Senate, and of a clear majority of the entire membership of the United States Senate. Further, the academic community was in such agreement with these recommendations that sixty prominent American educators volunteered to continue their assessment and guidance for a period of three years without compensation. Among these educators were high ranking officers of the American Association for the Advancement of Science, American Nurses' Association, American Political Science Association, American Psychological Association, American Sociological Association, Educational Testing Service, Great Plains National Television, Minnesota Department of Education, National Association for Public Continuing and Adult Education, National Council of Teachers of Mathematics, National Council on Measurement in Education, New Jersey Office of State Colleges, New York State Department of Education, School Science and Mathematics Association, Social Science Education Consortium, and United Negro College Fund.

A description of this massive needs assessment was sent to the National Science Foundation last July. Quantity copies of the recommendations resulting from this needs assessment were delivered to the National Science Foundation last September. This January, fully one quarter of the blue ribbon academic group volunteered to travel to Washington on their own time in order to explain and respond to possible questions which the National Science Foundation might have.

In considering your earlier discussion with Ms. Singleton, in which each of you wondered why such a needs assessment had not been done, my thought is, that perhaps you and others were never told it had been done; because it had been done under the auspices of two year colleges, the new boys on the street, rather than the friendly faces through which NSF is more used to receiving information. It is hoped that these facts may provide you with an alternative view of NSF's approaches to Community outreach and to the free dissemenation of information concerning Science Education.

Mr. Chairman, I appreciate this opportunity to present the AMATYC position on these issues of science education. Our position can be summarized by saying that we feel NSF needs a great deal of continuing prescriptive guidance from this Subcommittee.

Respectfully,

Dr. Joseph E. Cicero
President - AMATYC

Committee on Human Resources

Subcommittee on Health and Scientific Research

United States Senate

Edward Kennedy
(D.-Mass)

National Science Foundation

FY 78 Authorization

Statement submitted on behalf of the:

National Association for Equal Opportunity in Higher Education

by

Miles Mark Fisher, IV
Executive Secretary

April 6, 1977
Washington, D. C.

INTRODUCTION

The National Association for Equal Opportunity in Higher Education represents the historically black colleges and universities of this nation. These institutions continue to serve large numbers of black youth and similarly situated youth in this nation while graduating more than thirty thousands students annually with undergraduate, graduate and professional degrees from an annual enrollment numbering more than 200,000 students.

With the apparent retrenchment that is underway with regards to equal educational opportunity with achievement, these institutions continue to produce the critical number of students necessary to offset this trend while sustaining and expanding this effort.

Declining minority enrollments at Medical schools, Dental schools and in graduate opportunities signal a need for continuing the support of scientific programs for minorities if there is to be any broadening of participation in the future.

There is a critical need to increase the support of scientific activities which will expand the pool of prepared blacks and other minorities while broadening their participation in this nation's scientific endeavors. Blacks still lag behind in their preparedness across science oriented disciplines in American Higher Education and therefore are correspondingly underrepresented in all areas.

Unless the Federal Government takes a leadership role and provides the necessary resources both financial and human, the problem of underrepresentation and participation will be further exascerbated. It is in the national interest and in this nation's future that this problem be addressed in the First Year of the Third Century.

In a pluralistic society there is the need for greater participation by all of the citizenry, particularly in areas critical to the nations general well being. Chronic neglect of black colleges and other minority institutions must be reversed in order to remedy this situation.

As the pool of minority students continues to expand, opportunities will be provided to enhance the maximum utilization of this pool, particularly in scientific areas of endeavor.

The National Science Foundation has played a vital role in helping to raise the level of consciousness as to the direction minority activities should take at the minority institutions. However, resources going to these institutions must continue to be increased to accommodate in part the chronic underfunding of bygone years and meet present needs of these institutions.

If the nations commitment is to equal opportunity and improved representation of minorities in all fields, the following programs continue to be vital in keeping alive the minority thrust.

MINORITY INSTITUTIONS SCIENCE IMPROVEMENT

Minority institutions continue to need further developing and strengthening of the in science departments as well as expanding their fields of study. Science continues to be valued in our society and therefore should be maximized at minority institutions. The majority of black research scientists have received their college education and introduction to scientific disciplines at these institutions. A strong focus on these institutions will expand this nations scientific manpower resource pool.

The broadened eligibility criteria for this program suggests that the needs of these institutions vis a vis the Minority Institutions Science Improvement Program are far from being met. This program assists the Science Departments in broadening their curricula offerings in science related areas and therefore continues to be necessary.

Scientific preparation at the undergraduate level is the predicate for graduate and professional educational readiness if an adequate qualified pool is to be available. This program was initially funded at $5 million in FY 1972. FY 76 expenditures were $4.7 million. FY 77 funding is proposed at $5.1 million. FY 78 funding is proposed at $5 million. This level of funding does not take into consideration the inflation, expanding pool of eligible institutions and the new thrusts within institutions.

<u>We recommend that this program be funded at a level of $10 million for FY 1978</u>.

<u>MINORITY INSTITUTIONS GRADUATE TRAINEESHIPS</u>

This program is designed to improve the access of graduate students attending historically minority colleges and universities to careers in science and technology at those institutions which offer the master's or higher degrees in the sciences and are most productive in the number of degrees awarded.

The chronic underrepresentation of blacks and minorities in the science areas supports the expansion of such a program at minority institutions.

The FY 1978 Budget continues to encourage the highest quality standards in students and institutions by providing support for fellowships, traineeships and other student-oriented activities, and by increasing the entry into science of women and minorities historically underrepresented in these fields at a level of $1 million. The FY 77 Budget provides $900,000 for this program as a continuation of the thrust that began in FY 1974.

The House authorized that a floor of not less than $1,500,000 of its $3 million level of authorization be made available for a new program of Minority Graduate Scholars as a sub category under the Minority Institutions Graduate Traineeships. We are concerned that such a protective floor does not do justice to the Minority Institutions Graduate Traineeships which are given to Minority Institutions: This could be interpreted to mean that of the $3 million, $2 million could go to Minority Graduate Scholars while leaving a million for the original program thrust. Minority Institutions Graduate Programs need support, particularly those at the historically black colleges and universities.

We are aware that there was only one black student who received an NSF Fellows Award in 1975-76 out of a total of 550 awardees from a pool of 110 blacks. Sixteen ethnic group persons received awards and nine Asian or Pacific Islanders, six Hispanic and one black/Negro, not of Hispanic origin, together with the 534 Caucasions/whites not of Hispanic origin.

If the usual 550 awards would be allocated irrespective of race, then an additional 25 students (if alloted over three years) or 75 students (if alloted for just on year) would be conferred to minority applicants who did not receive one of the original 550 awards. Based on NSF's 1975-76 record, a possible 1 black plus 25 or/75 minority persons would participate in this program depending upon the allocation of the awards.

We recommend two separate programs:

A. Continuation of the present Minority Institutions Graduate Traineeship Program at a level of $2 million.

B. Establish the new program of Minority Graduate Scholars independent of the above program at $1.5 million as suggested by the House in its authorization deliberations.

These programs should be line itemized separately so that there is no danger of an absorption of the Minority Institutions Graduate Traineeship Program by the Minority Graduate Scholars Program.

MINORITY CENTERS FOR GRADUATE EDUCATION

This program is designed to promote increased participation by disadvantaged ethnic minorities in careers in science and engineering.

Several of these centers should be placed at the historically black colleges, namely: (Howard University) (Atlanta University Center) (Meharry Medical College/Fisk/Tennesse State University) and expanded to other centers.

Serious consideration should be given to those minority institutions that have a track reward of producing graduates rather than giving these centers to those institutions which are making promises but have not over time demonstrated a serious commitment to producing graduates.

This program should focus on building the capabilities of Minority institutions in that the Foundation has bypassed these institutions in its past efforts at Centers of Excellence. This can be rectified at this time.

In FY 77 the Foundation plans to spend $800,000 on Minority Centers for Graduate Education. This is a good concept in principle. However, the proposed $1 million for FY 78 is not enough money to adequately move this program.

Other research money should be looked at within the funding base of the Foundation in order that this new initiative have the potential for long term success based on the possibility of broad funding within the mainstream of funding.

<u>We recommend that this program be funded at $6 million for FY 78</u>.

<u>MINORITIES, WOMEN AND HANDICAPPED IN SCIENCE</u>

Funds under this program should be continued to expand the participation by these three groups in science activities. These three groups make up better than 2/3rds of the population. This program should ensure an even distribution of these funds across these areas.

<u>We recommend that this program be funded at $3 million for FY 78</u>. (A million for each of the designated areas in this program.)

RESEARCH INITIATION GRANTS AT MINORITY INSTITUTIONS

This program continues to support research of faculty members at minority institutions that were founded to serve the educational needs of ethnic minorities by providing research opportunities that would not have been otherwise possible.

This program should be continued in order to provide research opportunities for faculty members who are outside of mainstream research opportunities.

We recommend that this program be funded at a level of $2 million for FY 78.

COMPUTER TECHNOLOGY IN MINORITY INSTITUTIONS

Advances in educational technology continue to impact upon the teaching learning process. Much of the present classroom achievement is directly related to efforts put forth by the National Science Foundation. Research into the potential instructional value held by the electronic computer was a primary concern of the National Science Foundation; however, the 1968 program which concentrated on developing the potential of computer utilization in education might be considered less than impartial.

The Foundation was selective and it was also exclusive. Excluded were institutions enrolling large numbers of disadvantaged minorities. Computerized instruction and supportive computerized programs at predominantly black institutions are either inadequate or nonexistent.

The National Science Foundation's Minority Institute Science Improvement Program is not equipped to provide the support nor resources required to improve computer facilities, or, to train teaching faculty. It is necessary to underscore the pernicious need for the utilization of instructional technology simply to assess student entry behavior. The need to assess students so that faculty can redesign curriculum which meets the student where he is and respond to his cognitive style.

We support an initiative for this program at a level of $1 million.

Science Manpower improvement offers hope in the area of Fellowships and Traineeships, Student-Oriented Programs, Minorities, Women and Handicapped in Science and Facility Improvement. Increased minority participation in each of these subareas will have a tremendous impact over time if supported at a reasonable level.

IN SUMMARY

Existing programs hampered by present restraints must be allowed support which moves them against the current cutbacks in the present funding patterns.

The critical mass of productive black students will continue to come in the very near future from these institutions. These institutions must be strengthened in order that they might continue to provide that supportive encouragement which enables thousands of students to come to terms with their academic aspirations. The Minority institutions must be utilized as a resource for expanding scientific manpower.

We hope that this committee will support the following minority efforts, namely:

(1)	Minority Institutions Science Program	$10 million
(2)	Research Initiatives and Support for Minorities	$ 2 million
(3)	Minority Centers for Graduate Education	$ 6 million
(4)	Minority Institutions Traineeships	$ 2 million
(5)	Minority Graduate Scholars	$1.5 million
(6)	Minorities, Women and Handicapped in Science	$ 3 million
(7)	Computer Technology in Minority Institutions	$ 1 million

The minimum minority thrust as represented by the above programs should not be viewed as limiting the participation of minorities within the ongoing programs and activities of the Foundation. These figures represent floors to be expanded upwards with the report of the other august body. Minority participation across programs, minority institutions participation across programs and expanded minority participation at policy levels and on policy boards within the National Science Foundation are the minimum expectations of black Americans.

APPENDIX A

BLACK JUNIOR, FOUR-YEAR, GRADUATE AND PROFESSIONAL INSTITUTIONS
Enrolling in excess of 200,000 students

PENNSYLVANIA (2)
- Cheyney State College ★■
- Lincoln University ★●

OHIO (2)
- Central State University ★●
- Wilberforce University +●

MARYLAND (3)
- Bowie State College ★■
- Coppin State College ★■
- Morgan State College ★■

KENTUCKY (2)
- Kentucky State University ★●▲♦
- Simmons University +●

MICHIGAN (1)
- Shaw College at Detroit +●

DISTRICT OF COLUMBIA (4)
- D.C. Teachers College ★●
- Federal City College ★■♦
- Howard University +■
- Washington Technical Institute ★O♦

MISSOURI (1)
- Lincoln University ★■♦

ARKANSAS (4)
- Arkansas Baptist College +●
- Philander Smith College +●
- Shorter College +O
- University of Arkansas ★●♦ (Pine Bluff)

DELAWARE (1)
- Delaware State College ★●♦

NORTH CAROLINA (12)
- Barber-Scotia College +●
- Bennett College +●
- Elizabeth City State University ★●
- Fayetteville State University ★●
- Johnson C. Smith University +●
- Kittrell College +O
- Livingstone College +●
- N. C. A&T State University ★●♦
- North Carolina Central University ★■
- Shaw University +●
- St. Augustine's College +●
- Winston-Salem State University ★●

OKLAHOMA (1)
- Langston University ★●♦

VIRGINIA (6)
- Hampton Institute +■
- Norfolk State College ★●
- St. Paul's College +●
- The Virginia College +●
- Virginia State College ■★▲♦
- Virginia Union University +■

TENNESSEE (7)
- Fisk University +■
- Knoxville College +●
- Lane College +●
- LeMoyne-Owen College +●
- Meharry Medical College +▲
- Morristown College +O
- Tennessee State University ★■▲♦

SOUTH CAROLINA (8)
- Allen University +●
- Benedict College +●
- Claflin College +●
- Clinton Jr. College +O
- Friendship Jr. College +O
- Morris College +●
- South Carolina State College ★■♦
- Voorhees College +●

TEXAS (9)
- Bishop College +●
- Huston-Tillotson College +●
- Jarvis Christian College +●
- Paul Quinn College +●
- Prairie View A&M College ★■♦
- Southwestern Christian College +O
- Texas College +●
- Texas Southern University ★■
- Wiley College +●

LOUISIANA (6)
- Dillard University +●
- Grambling State University ★●
- Southern University (1) ★■♦
- Southern University (2) ★●
- Southern University (3) ★O
- Xavier University +■

ALABAMA (13)
- Alabama A & M University ★■♦
- Alabama Lutheran Academy +O
- Alabama State University ★■
- Bishop State Jr. College ★O
- Daniel Payne College +●
- Lomax-Hannon College +O
- Miles College +●
- Oakwood College +●
- Selma University +●O
- Stillman College +●
- Lawson State Community College ★O
- Talladega College +●
- Tuskegee Institute +■

GEORGIA (10)
- Albany State College ★■
- Atlanta University +▲
- Clark College +●
- Fort Valley State College +■♦
- Interdenominational Theological Center +▲
- Morehouse College +●
- Morris Brown College +●
- Paine College +●
- Savannah State College ★■
- Spelman College +●

MISSISSIPPI (12)
- Alcorn A & M University ★●♦
- Coahoma Jr. College ★O
- Jackson State University ★●
- Mary Holmes College +O
- Mississippi Industrial College +●
- Mississippi Valley State University ★
- Natchez Jr. College +O
- Prentiss Normal & Industrial Institute +O
- Rust College +●
- Saints Jr. College +O
- Tougaloo College +●
- Utica Jr. College ★O

FLORIDA (4)
- Bethune-Cookman College +●
- Edward Waters College +●
- Florida A & M University ★■♦
- Florida Memorial College +●

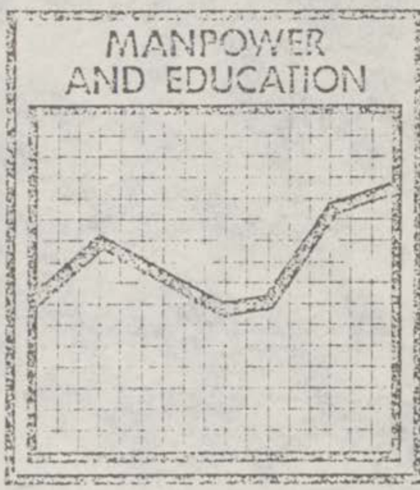
LEGEND

- Private +
- Public ★
- Junior College O
- Senior College ●
- Senior With Grad School ■
- Graduate School ▲
- Land Grant Institution ♦

INSTITUTION	FOUNDED	LOCATION
ALABAMA (13)		
Alabama A & M University	1875	Normal, Alabama 35762
Alabama Lutheran Academy	1922	Selma, Alabama 36701
Alabama State University	1874	Montgomery, Alabama 36101
Bishop State Jr. College	1965	Mobile, Alabama 36603
Daniel Payne College	1889	Birmingham, Alabama 35212
Lomax-Hannon College	1893	Greenville, Alabama 36037
Miles College	1905	Birmingham, Alabama 35064
Oakwood College	1896	Huntsville, Alabama 35806
Selma University	1878	Selma, Alabama 36701
Stillman College	1876	Tuscaloosa, Alabama 35401
Lawson St. Comm. Col.	1965	Birmingham, Alabama 35221
Talladega College	1867	Talladega, Alabama 35160
Tuskegee Institute	1881	Tuskegee, Alabama 36088
ARKANSAS (4)		
Arkansas Baptist College	1884	Little Rock, Arkansas 72202
Philander Smith College	1877	Little Rock, Arkansas 72203
Shorter College	1886	Little Rock, Arkansas 72114
University of Arkansas (Pine Bluff)	1873	Pine Bluff, Arkansas 71601
DELAWARE (1)		
Delaware State College	1891	Dover, Delaware 19901
DISTRICT OF COLUMBIA (4)		
D.C. Teachers College	1851	Washington, D.C. 20009
Federal City College	1968	Washington, D.C. 20001
Howard University	1867	Washington, D.C. 20001
Washington Technical Institute	1968	Washington, D.C. 20008
FLORIDA (4)		
Bethune-Cookman College	1904	Daytona Beach, Florida 32015
Edward Waters College	1866	Jackson, Florida 32209
Florida A & M University	1887	Tallahassee, Florida 32307
Florida Memorial College	1879	Miami, Florida 33054
GEORGIA (10)		
Albany State College	1903	Albany, Georgia 31705
Atlanta University	1865	Atlanta, Georgia 30314
Clark College	1869	Atlanta, Georgia 30314
Fort Valley State College	1895	Fort Valley, Georgia 31030
Interdenominational Theological Center	1958	Atlanta, Georgia 30314
Morehouse College	1867	Atlanta, Georgia 30314
Morris Brown College	1881	Atlanta, Georgia 30314
Paine College	1882	Augusta, Georgia 30901
Savannah State College	1890	Savannah, Georgia 31400
Spelman College	1881	Atlanta, Georgia 30314
KENTUCKY (2)		
Kentucky State University	1886	Frankfort, Kentucky 40601
Simmons University	1879	Louisville, Kentucky 40210
LOUISIANA (6)		
Dillard University	1869	New Orleans, Louisiana 70122
Grambling State University	1901	Grambling, Louisiana 71245
Southern University (1)	1880	Baton Rouge, Louisiana 70813
Southern University (2)	1959	New Orleans, Louisiana 70813
Southern University (3)	1964	Shreveport, Louisiana
Xavier University	1925	New Orleans, Louisiana 70125
MARYLAND (3)		
Bowie State College	1865	Bowie, Maryland 20715
Coppin State College	1900	Baltimore, Maryland 21216
Morgan State College	1867	Baltimore, Maryland 21212
MICHIGAN (1)		
Shaw College at Detroit	1936	Detroit, Michigan 48202
MISSISSIPPI (12)		
Alcorn A & M University	1871	Lorman, Mississippi 39096
Coahoma Jr. College	1949	Clarksdale, Mississippi 38614
Jackson State University	1877	Jackson, Mississippi 39217

INSTITUTION	FOUNDED	LOCATION
Mary Holmes College	1892	West Point, Mississippi 39773
Mississippi Industrial College	1905	Holly Springs, Mississippi 38635
Mississippi Valley State University	1950	Itta Bena, Mississippi 38941
Natchez Jr. College	1884	Natchez, Mississippi 39120
Prentiss Normal & Industrial Institute	1907	Prentiss, Mississippi 39474
Rust College	1866	Holly Springs, Mississippi 38635
Saints Jr. College	1954	Lexington, Mississippi 39095
Tougaloo College	1869	Tougaloo, Mississippi 39175
Utica Jr. College	1903	Utica, Mississippi 39175
MISSOURI (1)		
Lincoln University	1866	Jefferson City, Missouri 65101
NORTH CAROLINA (12)		
Barber-Scotia College	1867	Concord, North Carolina 28025
Bennett College	1873	Greensboro, North Carolina 27402
Elizabeth City State University	1891	Elizabeth City, North Carolina 27909
Fayetteville State University	1877	Fayetteville, North Carolina 28301
Johnson C. Smith University	1867	Charlotte, North Carolina 28208
Kittrell College	1886	Kittrell, North Carolina 27544
Livingstone College	1879	Salisbury, North Carolina 28144
N. C. A&T State University	1891	Greensboro, North Carolina 27411
North Carolina Central University	1910	Durham, North Carolina 27707
Shaw University	1865	Raleigh, North Carolina 27602
St. Augustine's College	1867	Raleigh, North Carolina 27602
Winston-Salem State University	1892	Winston-Salem, North Carolina 27102
OHIO (2)		
Central State University	1887	Wilberforce, Ohio 45384
Wilberforce University	1856	Wilberforce, Ohio 45384
OKLAHOMA (1)		
Langston University	1897	Langston, Oklahoma 73050
PENNSYLVANIA (2)		
Cheyney State College	1837	Cheyney, Pennsylvania 19319
Lincoln University	1854	Lincoln University, Pennsylvania 19352
SOUTH CAROLINA (8)		
Allen University	1870	Columbia, South Carolina 29204
Benedict College	1870	Columbia, South Carolina 29204
Claflin College	1869	Orangeburg, South Carolina 29115
Clinton Jr. College	1894	Rock Hill, South Carolina
Friendship Jr. College	1891	Rock Hill, South Carolina 29732
Morris College	1908	Sumter, South Carolina 29150
South Carolina State College	1896	Orangeburg, South Carolina 29115
Voorhees College	1897	Denmark, South Carolina 29042
TENNESSEE (7)		
Fisk University	1866	Nashville, Tennessee 37203
Knoxville College	1875	Knoxville, Tennessee 37921
Lane College	1882	Jackson, Tennessee 38301
LeMoyne-Owen College	1870	Memphis, Tennessee 38126
Meharry Medical College	1876	Nashville, Tennessee 37208
Morristown College	1881	Morristown, Tennessee 37814
Tennessee State University	1909	Nashville, Tennessee 37203
TEXAS (9)		
Bishop College	1881	Dallas, Texas 75241
Huston-Tillotson College	1876	Austin, Texas 78702
Jarvis Christian College	1912	Hawkins, Texas 75765
Paul Quinn College	1872	Waco, Texas 76703
Prairie View A&M College	1876	Prairie View, Texas
Southwestern Christian College	1949	Terrell, Texas 75160
Texas College	1894	Tyler, Texas 75703
Texas Southern University	1947	Houston, Texas 77004
Wiley College	1873	Marshall, Texas 75670
VIRGINIA (6)		
Hampton Institute	1868	Hampton, Virginia 23368
Norfolk State College	1935	Norfolk, Virginia 23504
St. Paul's College	1888	Lawrenceville, Virginia 23868
The Virginia College	1888	Lynchburg, Virginia 24501
Virginia State College	1882	Petersburg, Virginia 23803
Virginia Union University	1865	Richmond, Virginia 23220

APPENDIX B



Black College Graduates and the Job Market in the South, 1980

SOUTHERN REGIONAL EDUCATION BOARD

Table 1

Degrees to Blacks, Predominantly and Non-Predominantly Black Colleges, Southern Region, 1973-74 (Bachelor's Degrees)

	Predominantly Black Colleges			Non-Predominantly Black Colleges*		
	Male	Female	Total	Male	Female	Total
Agriculture	209	5	214	10	0	10
Architecture	22	1	23	18	2	20
Biological Sciences	451	415	866	74	83	157
Business & Management, less Accounting	2,080	1,263	3,343	540	220	760
Accounting	357	250	607	91	25	116
Communications	25	49	74	36	25	61
Computer Sciences	37	22	59	19	6	25
Education	1,879	5,525	7,404	482	936	1,418
Engineering	489	7	496	85	21	106
Fine & Applied Arts	142	138	280	108	69	177
Foreign Languages	29	132	161	17	24	41
Health Professions	76	434	510	18	185	203
Home Economics	3	322	325	2	104	106
Letters	188	717	905	117	237	354
Library Sciences	1	25	26	2	8	10
Mathematics	297	297	594	71	71	142
Physical Sciences	234	79	313	67	34	101
Psychology	192	395	587	83	114	197
Public Affairs	255	446	701	43	48	91
Social Sciences & Area Studies	2,349	2,257	4,606	313	639	952
Other	80	34	114	18	2	20
Total	9,395	12,813	22,208	2,214	2,853	5,067

*Estimated

Table 2

Degrees to Blacks, Predominantly and Non-Predominantly Black Colleges, Southern Region, 1973-74 (Master's Degrees)

	Predominantly Black Colleges			Non-Predominantly Black Colleges*		
	Male	Female	Total	Male	Female	Total
Agriculture	30	2	32	5	0	5
Architecture	19	4	23	0	0	0
Biological Sciences	43	45	88	9	9	18
Business & Management, less Accounting	148	35	183	90	55	145
Accounting	0	0	0	8	4	12
Communications	0	0	0	3	9	12
Computer Sciences	0	0	0	3	0	3
Education	1,358	2,480	3,838	240	339	579
Engineering	10	0	10	18	0	18
Fine & Applied Arts	6	12	18	30	18	48
Foreign Languages	4	4	8	6	10	16
Health Professions	1	1	2	0	13	13
Home Economics	0	5	5	0	17	17
Letters	18	58	76	11	59	70
Library Sciences	19	110	129	0	5	5
Mathematics	16	15	31	34	9	43
Physical Sciences	27	13	40	14	2	16
Psychology	40	73	113	3	6	9
Public Affairs	24	51	75	50	123	173
Social Sciences & Area Studies	129	113	242	62	20	82
Other	1	3	4	9	6	15
Total	1,892	3,025	4,917	595	704	1,299

*Estimated

Table 5

Favorable Job Outlook and Black Underrepresentation, Southern Region, 1980

	Total Projected Average Annual Openings, 1975-80 For College Graduates	Southern Region Total Projected Annual Market-Ready College Graduates, 1980	Black Projected Market-Ready Annual College Graduates 1980	Index of Black Representation
Engineering	10,900-11,500	11,800	500-550	39
Accounting	5,700- 6,900	6,650	550-600	72
Library Science	2,400- 2,600	1,500-1,900	100-150	79
Computer Sciences	2,600- 3,200	1,100	70-100	58
Urban and Regional Planning	200- 300	200	*	75
Medical Laboratory Technology	2,100- 2,500	2,000	150-200	73
Hospital and Health Care Administration	1,200- 1,500	500	*	**
Nursing	4,200- 5,400	4,900	350-400	62
Dentistry	1,500- 1,690	1,400	55- 60	34
Medical and Osteopathy	4,100- 5,500	4,000	200-250	49
Veterinary Medicine	750- 800	650	*	60
Optometry	200- 300	300	NA	NA
Occupational and Physical Therapy	1,500- 2,000	500	*	**
Dental Hygiene	200- 300	300	*	**
Medical Record Librarianship	300	100	*	**

*Less than 50
**Less than 10

Figure 1

Supply and Demand Balances and Representation of Blacks for Selected Fields of Study

	Blacks Underrepresented	**Blacks Overrepresented***
Total Demand Exceeds Total Supply of Graduates	Engineering Accounting Computer Sciences Public Administration Hospital Administration Medicine Dentistry Veterinary Medicine Nursing Optometry Other Health Fields	Social Work Business and Management
Total Supply Exceeds Total Demand For Graduates	Law Communications Library Sciences Foreign Languages Fine & Applied Arts Letters Psychology	Education Social Sciences

*"Overrepresented" refers only to the average black representation in all fields of study, and not to the actual percentage of black representation in employment.

Summary and Conclusions

Supply-demand balances of projected graduates in a discipline and relevant occupational openings are important for black college students as they weigh their choice of majors. Although affirmative action programs to overcome black underrepresentation in most professional-technical and managerial occupations may benefit black college graduates, the job search will be easier still for those having degrees in fields where job openings exceed numbers of emerging graduates of both races.

Blacks have made progress in recent years through greater participation in higher education and wider representation over an array of college majors. For example, the prior concentration of black college students in the field of education has been reduced, and their representation in engineering has grown recently. Yet more dispersion across fields of study should occur if black college graduates wish to take full advantage of opportunities created by labor market conditions.

Academic majors which appear promising, and where black students have been considerably underrepresented, include engineering, accounting, computer sciences and the health fields. Although many black students complete two-year programs in the allied health fields, employment opportunities will also be favorable for those completing four-year degrees. Efforts to increase black participation in the health professions (medicine, dentistry, veterinary medicine, optometry and podiatry) should continue not only from an equity viewpoint, but also because of excellent opportunities in the job market.

Business and management is another excellent field in which blacks are urged to major in all the various subspecialties. Blacks are not as seriously underrepresented in the business-management academic areas as they once were, but there is ample opportunity for more to shift to such studies without danger of overcrowding the field. Administrative capabilities will be greatly sought after in all enterprises, so that specialized administrative fields (hospital and health care, public, hotel and restaurant, etc.) appear favorable from a job market perspective.

Education and the social sciences, both areas in which blacks traditionally have tended to concentrate, face poor employment prospects for all races. There are some specialties in the social sciences, such as economics, where the outlook is better, but blacks have tended to major in sociology. The popularity of social work among black students has made this a field in which they have a higher employment ratio than they do in the population generally. Social work may again become a promising field in terms of job opportunities if governmental funding policies resume the trend of the late 1960's and early 1970's.

Many of the fields in which blacks have been underrepresented and for which the employment outlook is favorable are academic disciplines requiring a strong background in mathematics. Engineering, accounting, computer sciences and economics all have favorable employment prospects, and are fields in which mathematics are applied. It is easier for a student to embark in one of these areas if he or she comes prepared with a strong mathematical background, obtained at the high school and early college levels. It is harder to take advantage of these promising career options if a student must first "catch up" in math. Therefore, black students are urged to take rigorous mathematics courses at the high school and early college levels in order to improve their options to include a variety of fields with good employment opportunities.

The job outlook is not the only consideration in choosing fields of study for black students, any more than it is for white students. Students of all races have other objectives to be satisfied from higher education. Therefore, the humanities will have takers regardless of what the job outlook may be. Students who wish to fulfill non-vocational objectives by majoring in the liberal arts are certainly not to be discouraged from such plans by the projections of manpower-related reports. Those who wish to combine non-vocational objectives with an ounce of practicality are urged to do so by including skills courses that are readily applied to employment. In some instances double majors may be required, a combination of major and unrelated minor, or even an extra quarter or semester in college. This extra effort may be the price required in pursuing education for its own sake, while hedging to support practical needs.

Senator KENNEDY. The subcommittee stands in recess.

[Whereupon, at 12:30 p.m., the subcommittee adjourned, subject to the call of the Chair.]

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