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NATIONAL SCIENCE FOUNDATION AUTHORIZATION, 1971

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HEARINGS

BEFORE THE

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SPECIAL SUBCOMMITTEE ON
NATIONAL SCIENCE FOUNDATION

OF THE

COMMITTEE ON

LABOR AND PUBLIC WELFARE
UNITED STATES SENATE

NINETY-FIRST CONGRESS

SECOND SESSION

ON

S. 3700

TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES OF THE
NATIONAL SCIENCE FOUNDATION

S. 3412

TO AUTHORIZE APPROPRIATIONS FOR ACTIVITIES OF THE
NATIONAL SCIENCE FOUNDATION

APRIL 16, AND 23, 1970

Printed for the use of the Committee on Labor and Public Welfare



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NATIONAL SCIENCE FOUNDATION AUTHORIZATION, 1971

THURSDAY, APRIL 16, 1970

U.S. SENATE,
SPECIAL SUBCOMMITTEE ON THE
NATIONAL SCIENCE FOUNDATION
OF THE COMMITTEE ON LABOR AND PUBLIC WELFARE,
Washington, D.C.

The subcommittee met at 9:30 a.m., pursuant to call, in room 1313, New Senate Office Building, Senator Edward M. Kennedy (chairman of the special subcommittee) presiding.

Present: Senators Kennedy, Prouty, and Pell.

Staff member present: Roy H. Millenson, minority staff member.

Senator KENNEDY. Today the Special Subcommittee on National Science Foundation begins its hearings on the 1971 authorization for the Foundation.

We are meeting at a crucial period in the history of American science. Science and scientists are facing both unprecedented criticism and unprecedented opportunity. The critics contend that our scientific resources are too heavily concentrated in the defense area and that our scientific technology has too often ignored the needs of our environment. But even these critics must recognize how much we require science's help if we are now to cure our domestic ills, including pollution. That is the opportunity facing science today.

I believe that our scientific community may soon be better able to serve our domestic needs than it has been for a generation. This Nation is finally ready to reduce its military spending and to reorder its priorities. With intelligent support by the Government, we should be able to put new scientific resources to the task of solving environmental, health, and urban problems.

The NSF has a major role to play in enabling scientists to meet the challenge of the seventies. Through its support for basic research and science education, the NSF prepares the way for important discoveries. Through its support for applied research and the social sciences, it can help mission-oriented agencies at every level of government utilize these discoveries effectively.

The administration recognizes the significance of the NSF's role and has increased its authorization in 1971. But, in my view, the administration's authorization does not adequately take into account the overall research picture. It now appears that in 1970 the Department of Defense, NASA, AEC, and HEW will reduce their support for academic research by at least \$60 million. Many of the projects dropped by these agencies are of such high quality that the NSF

will want to fund them. But under the administration's authorization, the NSF will not be able to fund more than a fraction of them without cutting off other worthwhile projects.

The spokesmen for the NSF, who we are hearing today, must, of course, defend the Administration authorization. I intend, however, to probe deeply into their views on the impact that the Administration request will have on scientific research. And at our future hearings this subcommittee will invite outside experts to appraise the current needs of the NSF and the scientific community. In this regard I am happy to announce that on April 23 the subcommittee will hear testimony from the four former scientific advisors to the President—Dr. Killian, Dr. Kistiakowsky, Dr. Wiesner, and Dr. Hornig—as well as from a representative of the present advisor, Dr. DuBridge.

Our distinguished witnesses today are Dr. Philip Handler, Chairman of the National Science Board and President of the National Academy of Sciences and Dr. William McElroy, Director of the NSF. We have under consideration two separate bills, S. 3412, introduced by Senator Prouty, and S. 3700, which I introduced and which increases the Administration authorization by \$50 million.

I will ask that they both be printed in the hearing record.
(The text of the bills referred to follows:)

91ST CONGRESS
2D SESSION

S. 3700

IN THE SENATE OF THE UNITED STATES

APRIL 9, 1970

Mr. KENNEDY introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*
3 That there is hereby authorized to be appropriated, out of
4 any money in the Treasury not otherwise appropriated, to
5 the National Science Foundation \$548,000,000 for the fiscal
6 year ending June 30, 1971, and such sums as may be neces-
7 sary for the succeeding fiscal year, to enable it to carry out its
8 powers and duties under the National Science Foundation
9 Act of 1950, as amended, and under title IX of the National
10 Defense Education Act of 1958.

1 SEC. 2. Appropriations made pursuant to authority pro-
2 vided in section 1 shall remain available for obligation, for
3 expenditure, or for obligation and expenditure, for such period
4 or periods as may be specified in Acts making such appro-
5 priations.

6 SEC. 3. Appropriations made pursuant to this Act may
7 be used, but not to exceed \$2,500 in any fiscal year, for
8 official reception and representation expenses upon the ap-
9 proval or authority of the Director of the National Science
10 Foundation, and his determination shall be final and conclu-
11 sive upon the accounting officers of the Government.

12 SEC. 4. In addition to such sums as are authorized by
13 section 1 hereof, not to exceed \$2,000,000 is authorized to be
14 appropriated for each of the fiscal years ending June 30,
15 1971, and June 30, 1972, for expenses of the National Sci-
16 ence Foundation incurred outside the United States to be
17 paid for in foreign currencies which the Treasury Department
18 determines to be excess to the normal requirements of the
19 United States.

20 SEC. 5. This Act may be cited as the "National Science
21 Foundation Authorization Act of 1971".

91ST CONGRESS
2^D SESSION

S. 3412

IN THE SENATE OF THE UNITED STATES

FEBRUARY 6, 1970

Mr. PROUTY introduced the following bill; which was read twice and referred to the Committee on Labor and Public Welfare

A BILL

To authorize appropriations for activities of the National Science Foundation.

1 *Be it enacted by the Senate and House of Representa-*
2 *tives of the United States of America in Congress assembled,*
3 That there is hereby authorized to be appropriated, out of
4 any money in the Treasury not otherwise appropriated, to
5 the National Science Foundation \$498,000,000 for the fiscal
6 year ending June 30, 1971, and such sums as may be
7 necessary for the succeeding fiscal year, to enable it to carry
8 out its powers and duties under the National Science Foun-
9 dation Act of 1950, as amended, and under title IX of the
10 National Defense Education Act of 1958.

11 SEC. 2. Appropriations made pursuant to authority pro-

1 vided in section 1 shall remain available for obligation, for
2 expenditure, or for obligation and expenditure, for such
3 period or periods as may be specified in Acts making such
4 appropriations.

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9 Foundation, and his determination shall be final and con-
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12 section 1 hereof, not to exceed \$2,000,000 is authorized to
13 be appropriated for each of the fiscal years ending June 30,
14 1971, and June 30, 1972, for expenses of the National
15 Science Foundation incurred outside the United States to be
16 paid for in foreign currencies which the Treasury Depart-
17 ment determines to be excess to the normal requirements of
18 the United States.

19 SEC. 5. This Act may be cited as the "National Science
20 Foundation Authorization Act of 1971".

Senator KENNEDY. Dr. Handler, we enjoyed very much your comprehensive testimony last year and we want to wish you a very warm and genuine welcome back this year. I thought if it was an acceptable way of proceeding that we might have you talk about the present state of the NSF and the scientific community and then we could hear Dr. McElroy give us a more detailed analysis of exactly what the NSF program is doing. Then I will have a number of questions that I hope both of you will respond to.

STATEMENT OF DR. PHILIP HANDLER, PRESIDENT, NATIONAL ACADEMY OF SCIENCES AND CHAIRMAN, NATIONAL SCIENCE BOARD

Dr. HANDLER. It is a great privilege to be here to discuss the authorization for the National Science Foundation for the upcoming fiscal year.

When the National Science Foundation was created in 1950—this year marks its 20th anniversary—it was envisioned as the agency which was to be the primary mechanism by which the people of the U.S. would support science.

But that vision has never been fulfilled. The reasons are not to be found within the National Science Foundation but, rather, in the fact that for a variety of causes it has been the mission agencies, ONR, AEC, NASA, National Institutes of Health, the Defense Department, the Department of Agriculture, which attracted the funds and have been major supporters of science in the United States in the two decades which have intervened.

The Science Foundation's budget has grown during this period, to be sure, but even now it provides only of the order of one-eighth of all Federal funds in support of fundamental science and one-sixth of all Federal funds in support of academic science.

Under these circumstances, nevertheless utilizing this pluralistic system, science in the United States has certainly prospered. Our scientific endeavor has been successful in all major areas of scientific concern. And the consequences are evident about us.

The economy has grown. The health of our people has improved steadily and defense of the country has been secured to the best ability of technology to achieve such security.

However, the growth of Federal funding began to taper off in fiscal year 1968 and has remained essentially static or declined in the years since.

But the scientific endeavor continues. It has by no means been dismantled and it continues to be successful. In the current year, however, the coloration of this enterprise has undergone a significant change. Increasingly, we hear that science will be called upon to engage in endeavors which are more closely related to the public purpose, as this is perceived, than it has in the past.

The clearest expression of that problem was the amendment, section 203, to the Defense Authorization Procurement Act last year which stated that the Defense Department should utilize the funds available to it only for those projects which bear a clear and apparent relation to a specific military function or operation.

I do not know whether such a restriction will again be placed upon the Defense Department's activities this year. But even should that not happen, last year's action will surely have had its effect and indeed its impact is not restricted to that department.

The philosophy has clearly spilled over on to other federal agencies which have specific missions, missions which are not specifically the health and vitality of scientific endeavor nor indeed the welfare of the institutions in which science is conducted.

As the funds available to these agencies have plateaued, those responsible for managing such agencies necessarily have defended their missions wherever funding the mission and funding science itself seem at odds.

Given a choice, and restricted funds, intelligent direction of such an agency necessarily will defend those activities which are most closely related to the mission.

It is not yet clear to what extent science is being damaged by that phenomenon. Some data are available and I think Dr. McElroy can make them available to you. Whatever the magnitude in dollars, those investigators who have lost DOD funding begin to read like a Who's Who in American physical science.

Without such legislation, an analogous process has been occurring at the National Institutes of Health which now must ask themselves, more sharply than they have had to do in the past, what is meant by "health related research." Up until now, they have been able to take a rather broad view of what that term really means.

Senator KENNEDY. I don't want to interrupt, but are you suggesting that at a time when there is a great need both in the natural sciences and the social sciences for long-range thinking budgetary belt-tightening is forcing scientists to look to the more immediate kind of problems rather than toward long-range thinking and planning and programing?

Dr. HANDLER. In a general sense, yes, sir. Those who give guidance to our scientific capability have two courses available to them at all times and both should be pursued. We must always utilize that information and understanding we do have, to the best of our ability, to improve the condition of man in the United States, to improve the public health, to secure defense, to deal with the growing problems of our cities, to deal with the population problem, to pursue the search for a stable peace.

A wide variety of endeavors can be furthered by utilization of scientific understanding. And where such understanding is available it should be utilized. Indeed, that is why we acquire it. At the same time, historically it has been evident that there is no predicting where useful information will come from. One should not warp the scientific endeavor by converting all of our capabilities into applied activities and forsaking long range scientific ventures.

We require a balanced activity. The Science Foundation attempts to so order its programs. In the past these have very largely been in more fundamental scientific areas but, by virtue of the act which you and Mr. Daddario sponsored last year, the license of the Foundation has been broadened and it now intends to enter more applied areas, albeit in a limited way.

Other agencies have licenses to use their funds for support of science but, necessarily, they have been taking an increasingly restricted view

of what aspects of science are permitted under such a license. If the total picture of Federal funding for science is such that funds available to the mission agencies are further restricted, then in the national interest, it is required that additional funds be placed in the budget of the Science Foundation to make sure that the long range capability of science is preserved.

If one traces any technological capability back to its origins, there are few such stories that do not go back 30, 40 or 50 years to the time when the scientific basis for a new technology became apparent. We must get on with the fundamentals today so that we will have the understanding we will surely require in a rather long distant future. Meanwhile, we use the information we do have as best we can.

The clearest examples known to me of changes in program, without any legislation to compell it, were the actions of the National Institutes of Health in which they have markedly reduced the support they formerly provided for organic chemistry and for studies of photosynthesis and other aspects of the plant physiology.

It was almost an accident that the National Institutes of Health has been the principal supporter of academic organic chemistry in the United States. No Federal agency bears a one-to-one correspondence with the discipline of chemistry analogous to that of the Atomic Energy Commission with nuclear physics, or the Department of Agriculture with certain aspects of plant science. The interest of National Institutes of Health in organic chemistry derives from its interest in furthering capability for production of new drugs.

The Science Foundation provides support of organic chemistry but less than has NIH. Yet the academic venture in organic chemistry underlies a \$40 billion a year industry and is the major source of new ideas.

To have these funds cut back because of a narrowing vision by NIH of its mission, without providing at least equivalent funds from elsewhere in government would be a national mistake. Similarly, with respect to photosynthesis, the NIH considers itself necessarily forced to constrict programs because of fiscal reasons and the need to defend its mission proper.

Their problems are sick people and the prevention of disease. So they narrowed down their program in this area. A number of our most highly talented, accomplished investigators in the area of photosynthesis are now without support and they have been turning to the Science Foundation. Yet, there is no guarantee that the consequences of their studies will be applied only in the field of agriculture or horticulture. Much that we have learned from plants has been transferred to our ability to deal with human disease.

A case in point for example has been the history of a material which is called Poly I-Poly C (polyinosinic-polycytidylic acid).

The biological activity of this material was first observed in plants. But when given to animals, Poly I-Poly C resulted in production of another material, interferon, which in turn appears to be the natural mechanism to deal with infection by a virus. This is the material which is currently being tested against the common cold.

Another spectacular example that might be stated for this record is the history of a drug called cytosine arabinoside. This compound was found a few years ago by a zoologist engaged in study of comparative biochemistry of sea sponges.

It was present in the sponge in rather small quantity and was quite difficult to identify as it had never been seen before. Because of its structure, which was established by a biochemist, it suggested to all biologists that it might well be the kind of drug, which in a highly specific way could interfere with the cellular reproductive apparatus that is to say, the genetic apparatus. It was tested in both normal and cancer cells growing in culture and proved to be very highly effective. But the supply was limited.

The amount in sponges is minute and the supply of sponges is limited. So this was a challenge to the organic chemist. Several organic chemists attempted its synthesis—but without success. Perhaps the story would have ended there had it not been for another organic chemist who was then studying the kinds of chemical reactions which occur under conditions which are generally thought to be those which obtained on this earth before life appeared.

He was studying the kind of chemistry which supposedly occurred and gave rise to the organic compounds which made life possible.

In the course of those studies he came across an unfamiliar compound which took some months to identify. It proved to be the same material, cytosine arabinoside. This was a clue to a quite novel synthetic procedure and, in the end, because the man is a very competent and talented organic chemist, he developed a highly specific rather simple procedure for synthesis of this compound. It is now being tested widely across the country in leukemic children and is the most promising drug we have for the treatment of leukemia.

Again, an overly narrow license of National Institutes of Health might well have prevented them from exploring either the origins of life or the comparative biochemistry of sponges. Surely, there was no predicting that either of those studies would give rise to a useful drug for a dread disease.

Senator KENNEDY. I think you have given some marvelous illustrations and examples. I hope that we will be able to supplement these examples for the record because I think they are enormously valuable. I think what you are showing here is that you just cannot tell when these scientific studies are going to spin off in a meaningful way and meet some of the most basic needs of the people.

What we ought to be willing to do is give the kinds of support to the NSF or through the NSF to these other agencies to permit them as broad and wide a latitude to move in all the areas of science as the best scientific minds believe will ultimately prove useful.

Dr. HANDLER. You have put it very well, Senator Kennedy. That is the problem. There must be an amply funded Federal agency which has the broadest possible license to support science, without concern for what the ultimate applications will be.

That agency is the National Science Foundation. The Foundation must be ever alert to opportunities to utilize scientific understanding for societal benefit; but on a day-by-day basis, it can simply operate, based upon our historical articles of faith which have paid off repeatedly. There is no reason to consider that the findings of science, gained today or tomorrow, will be any less applicable to human affairs than has been the science which was done yesterday.

If for fiscal or other reasons, the programs of the mission agencies are to be constrained and narrowed, then, in the national interest, it is imperative that at least equivalent funds be placed in the appropriation to the National Science Foundation.

Dr. McElroy and I have come this week from the largest scientific meeting which is held in the United States, annually, the meeting of the Federation of American Societies for Experimental Biology. Some 22,000 scientists were there in Atlantic City.

It is clear from that meeting that biological science never was more exciting, never more competent than at the present time. But, as one walked about that meeting the sense of apprehension is almost a tangible, physical phenomenon.

Wherever we turned, inevitably almost everyone we encountered is concerned with Federal funding. All are concerned lest there not be funds to continue the scientific venture on the same scale in the future; this is particularly true of the young people.

What deeply troubled me at this meeting was the number of young scientists who said two kinds of things: (1) that they very much would like to have the opportunity to use the science they have been learning to deal with the problems of American society, for example, the environment, the quality of life in the city, peace, population, food problems, and so forth.

At the same time, (2) they expressed grave concern for the future because their reading is that, if the Federal Government really is no longer interested in the support of science, perhaps they have made a bad choice of a career and have wasted the training they have already had.

Now please understand, sir, that there is no evidence of unemployment of such young scientists at the present time. But there is ample evidence that there well might be such if current trends continue and the Federal Government significantly reduces its support of the scientific endeavor.

There can be no alternative to the Federal Government as the principal patron of science in these United States. Conversely, it is pointless for us to encourage our young people and then not assist them to do the research for which they are trained. If we are not to do research in the future, or reduce the scale markedly, we should let our young people know it.

If we are, however, then we must encourage them.

At the moment they feel very seriously discouraged as to what the future holds.

Senator KENNEDY. Let me ask you, on point No. 1, about scientists' willingness to start to embark on some of these new and demanding areas of social concern. We had some hearings on the problems of economic conversion in Massachusetts and the impact of conversion on a number of small and large companies. We met with a number of different technical and scientific witnesses who said that they felt it was going to be a very difficult kind of transition for many of them to move from some of the Space Agency technology into the perhaps more mundane kinds of problems of pollution and the urban crisis and population control.

At this meeting which you have just come from, did you find this to be an attitude held by some of the scientific community?

Dr. HANDLER. I guess that community falls into two parts. Most of the older members of that community would probably prefer to go on doing the fundamental research in which they have been engaged in the past. But remember that this is a biological science community; a large fraction of them are concerned with the problems of disease and these are just as important, just as relevant as they were yesterday.

I see no reason to turn them in other directions. And that is equally true of those who have been concerned with agricultural problems and with the problems of environmental health. These are real problems, relevant to the problems of the moment, and I see no reason to turn that group away from what they are doing. It is among the young people that the problem arises. It is the young scientists who are looking about for opportunities to use what they have learned to deal with the other types of problems which are of such common concern at this time.

Those opportunities are relatively few and the conversion is difficult, sir. It is not entirely obvious that their training can be directly brought to bear on our more apparent social problems.

Particularly when one considers that many of these problems may not really require new science in quite the same sense. They require regulatory actions, new engineering or new technology based on existing science. It is not fundamental science which is required to deal with the problems of solid waste for example. Or at least, it is not obvious that such is required. But these young people are imaginative and predictions based on past performance become absurd. History says that is not the way things have happened and, given an opportunity, there is no telling what they may do with their science with respect to these pressing problems.

But they lack good opportunities. We do not have an institutionalized set of arrangements within which they can work on such problems. To return to your specific question, for the kind of companies which have thrived, which have been engaged in the high technology of the day, it really is doubtful that their technological capabilities can be put to what you call "more mundane purposes." It would be a very difficult transition for them indeed.

In summary, Senator Kennedy, the members of the National Science Board and the scientific community at large really do believe that the spring of 1970 is different from other springs we have known in considering the disposition of the Federal budget.

For the first time, one can state, categorically, that the strength of the American scientific enterprise in the years ahead really will rest on the programs of the National Science Foundation. This is not a statement I could have made equally confidently in the past and with equal assurance that what I was saying was entirely correct because, in the past, the National Science Foundation was but one among many supporters of science in the Federal Government.

But it is clear that is not the way life will be in the future. As the mission agencies increasingly use the resources available to them to deal with the applied problems which are their principal concerns, if we are to have an adequate long-range scientific venture, if it is to be as strong as we would like so that science can be utilized for public purpose tomorrow, if we're not to just drain the supply of available information in a great hurry, then as of now, the Federal Government must begin to support the National Science Foundation as what it was intended to be, the principal instrument by which the Federal Government supports the basic science endeavor.

Other aspects of society may well appear to have more urgent calls upon the public purse, and one might certainly agree that, for a few years true growth of the scientific endeavor may be suspended. But let us not dismantle the national scientific apparatus, either. I mean the network of scientists and laboratories. And let us have a

few new starts. Since fiscal year 1968 the purchasing power available to science has decreased by about 25 percent, about 500,000,000 of 1958 dollars. It is too much to expect an equivalent increase in the fiscal year 1971 appropriation—but it is not too much to ask that that appropriation compensate for the concomitant decreases in the other Federal science-supporting agencies this year and recover a portion of previous losses. It is the national future which is at stake. Thank you.

Senator KENNEDY. Thank you very much, Dr. Handler.

(The following information was subsequently supplied for the record:)

U.S. SENATE,
Washington, D.C., April 27, 1970.

Dr. PHILIP HANDLER,
Chairman, National Science Board,
National Science Foundation,
Washington, D.C.

DEAR DR. HANDLER: Thank you very much for your extremely valuable testimony before the Special Subcommittee on the National Science Foundation. I think it was especially useful for the Subcommittee to hear your descriptions of "irrelevant" research which lead to important scientific and medical advances.

Because of the pressures of time, there were many areas which the Subcommittee did not get an opportunity to explore with you. I hope that you will feel free to amplify your testimony for the record. For example, I am sure the Subcommittee would be extremely interested in your views on the role and significance of the NSF's fellowship and traineeship programs.

Again, thank you for your excellent testimony.
Sincerely,

EDWARD M. KENNEDY.

P.S. Could you please give the Subcommittee some further examples of important contributions which have come from unexpected research sources?

NATIONAL SCIENCE FOUNDATION,
NATIONAL SCIENCE BOARD,
Washington, D.C., April 30, 1970.

Hon. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: This will acknowledge your kind letter of 27 April. Unfortunately I cannot provide the statement, in extenso, requested in that letter as it arrives just as I prepare for departure for a two week trip abroad on the business of the National Academy of Sciences.

The list of important contributions to our technological civilization which have come from unexpected research sources is almost a list of our technological accomplishments. To add an example from the physical world, it is apparent that the laser finds new applications in a remarkable range of uses with each passing week. Yet this device was originally constructed in its most primitive form as a means of checking certain predictions concerning the behavior of atoms which derived from quantum mechanical considerations of the nature of atomic structure. Once it had been determined that the ruby laser actually does provide a source of incredibly intense coherent light, interest in such sources increased at a great rate, leading in turn to rapid improvements in such instruments and the construction of gas lasers which are finding an even broader set of applications for both military and civilian purposes. Repeatedly, instances such as this have recurred in which a scientific development results in a piece of technology which is at first utilized for scientific purposes, becomes refined and made relatively foolproof for industrial purposes, thereby in turn providing an instrument which is utilized for the performance of more science in a never-ending circle.

In the biological realm such experience is commonplace. For example, consider the state of understanding of the intrinsic nature of neoplasia, the heart of the cancer problem.

The most promising lead to current understanding of neoplasia and accordingly the most promising source of ideas with respect to therapeutic procedures, has come from studies which initially were intended to understand genetics at the molecular level. In furthering progress in this area, intensive experimentation was undertaken in several laboratories on the mechanism of viral duplication in bacterial cells, utilizing viruses called bacteriophage which are without effect in man or any other animal. In the course of these studies it became clear that certain bacteriophages can infect bacteria and then seemingly become lost. They cannot be observed by microscopy, and the cells of the infected bacteria continue to divide and grow undisturbed. Yet if the environment of those cells is changed suddenly, the virus reappears, multiplies rapidly, and destroys its bacterial host.

This in turn became the model for what we now understand to be a highly probable mechanism for many forms of cancer. An invading virus—with which we may even have been born—loses its identity and its genetic material becomes incorporated in the chromosomes of our own cells. As our cells divide and reproduce, so too does the genetic material of the virus, although it is never visible as such. Then some small alteration in the environment of our own cells—analagous to that of the bacterial cells—causes a subtle change which results in the reappearance of the virus, or perhaps the complete takeover of the metabolism of the cell by the genetic instructions provided by that virus. It is this process which so alters the nature of the cell as to occasion rapid cellular multiplication uncontrolled by the normal mechanisms of the body, i.e., a tumor or cancer.

We have many documented instances now of this form of behavior and in turn this has led to some of the more important developments with regard to the construction of the next generation of anti-tumor therapeutic agents. But it should be clear that those scientists who originally hoped to explore the molecular mechanisms of bacterial genetics had not the faintest inkling that they were engaged in research on cancer.

I am pleased also to have been asked to comment upon the NSF Fellowship and Traineeship Programs. In my view, it is shortsighted in the extreme to ramp up with the national system for the production of scientists based only on current fiscal considerations or projections of science support in the next few years. The productive life of scientists is limited to 20 to 30 years at most. Our country is currently in the process of revising its national philosophy with respect to science, but one fact remains clear: Science remains the most powerful instrument we have for shaping the national future. No vision of that future is rational without an expanding body of scientists engaged in increasingly difficult investigative endeavors. The graduate students supported today will not be independent working scientists for almost ten years. If, a decade hence, it is clear that we shall wish to substantially expand the scientific endeavor—a projection which I cannot doubt—we will have foreclosed that option if funds are not provided today for the training of young scientists. It is not inconceivable that we will wish to rethink the mechanisms by which such support is to be provided. But until such a decision is clearly rendered, I would be much disturbed if we were to compromise the national future and foreclose our future options for lack of an adequate cadre of trained scientists.

Many young people in our country are already turning away from science because of increasingly frequent statements which lump science with technology and blame both for the deterioration of one or another aspect of the environment. But neither science nor technology can be so blamed in a rational way, only the manner in which our society, making judgments in a market economy, has in the past utilized the technology science has made possible can be so faulted. Yet such misguided statements in the public press increasingly are turning away young people from the thought of careers in science. If the Federal Government also fosters such attitudes by reducing support for the conduct of science and more importantly, by reducing support for the training of young scientists, the combination of these events will surely act to still further reduce the number of young people in training; and that will markedly limit the national scientific and technological capability in the future.

The nations of the world over which we held a large economic lead in the 50's and early 60's now compete successfully in the world's markets. The success of Japan and Germany, and the lesser success of France, Russia and Britain, are obvious to all. Unless we maintain our scientific and hence technological superiority, we cannot conceivably maintain a disparity between the standard of living in the United States and that of the lesser paid labor forces of the rest of the world. The edge we had was provided by our technical superiority. To maintain such superiority we must remain several jumps ahead scientifically or we shall

surely find ourselves uncompetitive in the world's markets. In that case, our standard of living would necessarily reduce to that of the nations with which we compete. The costs of science are cheap indeed in the light of such considerations.

Sincerely yours,

PHILIP HANDLER,
Chairman, National Science Board.

Senator KENNEDY. Dr. McElroy.

Senator PROUTY. Mr. Chairman.

Senator KENNEDY. Senator Prouty.

Senator PROUTY. Mr. Chairman, I am sorry I was detained. I welcome these hearings for they afford us several opportunities. One, to explore the progress of the National Science Foundation. Two, to probe new directions of our support for science research and education and, three, to welcome Dr. McElroy in his first appearance before our subcommittee. Of late I hear with increasing frequency the phrase "we don't know." It is easy to respond "well, we will find out." But I know it is not that easy. Today we seek to discover how best to use our resources to find out.

One thing I know is that the needed scientific research and education will take money. How much I cannot now say. Mr. Chairman, the two bills we are considering today (S. 3412 and S. 3700) differ only in those parts which follow the dollar signs.

Both bills provide authorizations for 2 years, thereby reflecting our mutual desire to maintain and accelerate our research momentum.

I trust these hearings will be helpful to our deliberations on those portions of the bills which differ.

STATEMENT OF DR. WILLIAM D. McELROY, DIRECTOR, NATIONAL SCIENCE FOUNDATION, ACCOMPANIED BY DR. LOUIS LEVIN, EXECUTIVE ASSOCIATE DIRECTOR; DR. EDWARD P. TODD, DEPUTY ASSISTANT DIRECTOR FOR RESEARCH; DR. T. O. JONES, ACTING DEPUTY ASSISTANT DIRECTOR FOR NATIONAL AND INTERNATIONAL PROGRAMS; DR. THOMAS D. FONTAINE, DEPUTY ASSISTANT DIRECTOR FOR EDUCATION; DR. HOWARD E. PAGE, ACTING DEPUTY ASSISTANT DIRECTOR FOR INSTITUTIONAL PROGRAMS; DR. CHARLES E. FALK, PLANNING DIRECTOR; BERNARD SISCO, ASSISTANT DIRECTOR FOR ADMINISTRATION; CLARENCE OHLKE, GOVERNMENT AND PUBLIC PROGRAMS DIRECTOR; WILLIAM J. HOFF, GENERAL COUNSEL; THOMAS E. JENKINS, DEPUTY ASSISTANT DIRECTOR FOR ADMINISTRATION; DR. HARVE J. CARLSON, DIRECTOR, DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES; DR. JOEL A. SNOW, HEAD, OFFICE OF INTERDISCIPLINARY RESEARCH; ROBERT B. ABEL, HEAD, OFFICE OF SEA GRANT PROGRAMS; AND DR. ARLEY T. BEVER, DEPUTY PLANNING DIRECTOR

Dr. McELROY. Thank you, Mr. Chairman and Senator Prouty. I welcome the opportunity to appear before you today for the second authorization hearing for the National Science Foundation and to present for your consideration the administration's program for fiscal year 1971.

This is my first opportunity to represent the Foundation in support of its programs before this committee; and also to share with you our joint responsibility for the continued development of new scientific knowledge; the improvement technology; and the improvement of science education required to sustain and advance our technology based society, both in the context of our Nation and as a Nation in the total world community.

I am sure that you are keenly aware of the growing fear on the part of many of our citizens, young and old, rich and poor, that both the prime products and the byproducts of our technologically based society may irreversibly disrupt the social and biological systems that support life, and thereby threaten the existence of life as we know it on this planet.

There is an expressed desire for the Nation's scientific, academic, and industrial enterprise to mount an appropriate response to the challenge posed by the continuing deterioration in the quality of our environment. We welcome the concern being shown by Congress, the President, and the people and we intend to respond to that concern.

My first point this morning is to emphasize the programs of the National Science Foundation in response to this national challenge, programs designed to provide the fundamental knowledge and trained manpower needed by mission agencies, industry and others to meet these pressing challenges.

Second, due to severe budget pressures and congressional mandate, I wish to emphasize the growing shift away from support of fundamental research by the mission agencies of the Federal Government. This is placing even greater pressure on the limited resources of the Foundation, and it will become increasingly difficult for the Foundation to ensure viable programs of scientific research at U.S. academic institutions.

Third, I wish to emphasize that the development of the scientific systems approach needed to deal with complex multidisciplinary investigations—such as our Biome Studies in the International Biological Program—require resources on a larger scale than have been required for the traditional research project support provided for investigations in a single area of science.

These three factors, responses to challenges of our times, increasing reliance on the Foundation for support of fundamental science and the increasing complexity of research itself, account for the administration-approved requested funding increase from the \$463.1 million available in fiscal year 1970 to the \$513 million fiscal year 1971 estimate.

It is too early to assess the full effect of the Mansfield amendment on the conduct of fundamental research by the Department of Defense, however we are aware that DOD as well as other mission agencies, including NASA, NIH and AEC, are reviewing their research budgets in detail and further significant reductions in funding for fundamental investigations above those already made, are likely to occur.

Senator KENNEDY. On this point, have you made an analysis of the cuts of the various mission oriented agencies in terms of their research in 1970.

Dr. McELROY. We have made an effort to do that.

Senator KENNEDY. What figures do you come out with?

Dr. McELROY. We have had figures compiled, and this is in addition to the Mansfield amendment, indicating that cuts due to their own budgetary pressures are of the order of \$50 to \$60 million.

We anticipate that a large number of extremely competent research investigators, whose support is being curtailed or terminated, will turn to the Foundation for continued support. Their proposals will have to compete on scientific merit with other proposals submitted to us.

Senator PROUTY. Could you describe some of those programs that are being cut now in these other mission oriented agencies for us?

Have you made a sufficient kind of study on this?

Dr. McELROY. I think we could supply you with a detailed list if you would like.

Senator KENNEDY. Would you?

I think it would be useful for this committee to know the nature of some of those cuts and we would be interested in any kind of appropriate comment you would like to make on those cuts and the people that are involved in them. I understand there are some extremely competent and knowledgeable scientists—even Nobel Prize winners—that are going to be cut by various agencies. Now, as I understand it, they will have to come in and compete with other requests before the NSF. Is that correct?

Dr. McELROY. Yes, sir, it is.

Senator KENNEDY. And you will have to make a judgment evaluating these additional requests against some of the more traditional kinds of requests.

Dr. McELROY. That is right.

Senator KENNEDY. And how much of the administration request is allocated to these mission oriented cutbacks?

Dr. McELROY. In our basic budget we have \$10 million which is specifically for increased proposal pressure. Now this category could also include, of course, applications from young people coming into the field so we have no way of really anticipating how much of the DOD dropouts we could pick up in that \$10 million. But that is all that is included in there.

Senator KENNEDY. So there will be between \$50 and \$60 million in cutbacks in mission-oriented agencies, and if the affected scientists attempt to continue their research and go to the NSF you would somehow have to try and find within that budget increase of \$10 million the funds to meet their requests plus the new requests by some of the younger scientists.

Dr. McELROY. That is right. Of course as I pointed out in the testimony it is impossible for us to determine at this time the effect of the Mansfield amendment until the Defense Department has received its appropriation.

Senator KENNEDY. So when you suggest this 50- to 60-million-dollar figure, that is a conservative figure.

Dr. McELROY. Right now it appears conservative.

Another concern generated by support requirements for additional senior investigators is the competitive position for grant funds for new young investigators. Within our limited funding, special measures may be needed to assure a minimum support level for new investigators.

The primary mission of the National Science Foundation has been and must continue to be, the fostering of fundamental research and improved education in the sciences. This effort must remain paramount, both in terms of funding and in the surveillance necessary to insure attainment of mission objectives. I want to assure the committee that this primary mission of the Foundation remains unchanged.

The major problems of our time might be broadly described as:

1. Problems related to the natural environment.
2. The social environment, and
3. The problems of the application of science to both, in the form of technology.

Solutions to these problems will require new knowledge and understanding only available from intensive research.

All three problem areas of concern require the contributions of virtually all of the sciences. In a real sense there are no "environmental sciences," per se, only sciences addressed to the study of environment, whether physics, chemistry, biology, engineering, or other. For this reason much of the work to be undertaken on these problems is necessarily multidisciplinary in character. And all three problem areas require efforts across a complete spectrum of scientific and engineering activity, from the most fundamental to the most practical.

The National Science Foundation, we believe, has a special responsibility and competence to respond to these new national concerns. Both through the passage of Public Law 90-407 and in the development of its proposed program, the Foundation has been recognized as an important intermediary between the scientific strength of the Nation, especially as embodied in its academic institutions, and the needs of the Nation. For this reason the Foundation has reexamined its programs, reassessed its priorities, and has begun to synthesize the new efforts that this role implies. The result constitutes an important extension of the Foundation's activities, but it is in no sense a replacement for the essential work the Foundation has supported over the years and hopes to continue to support at a higher level.

Our proposed additional activities should not be misunderstood. We do not attempt to balance relevance against irrelevance, for in my judgment, no scientific emphasis and, more importantly no scientific effort lacks eventual relevance to society. Rather it is a question of motivation, emphasis and more importantly one of timing.

Innumerable examples could be cited. The most remarkable of course begins with work during the first third of this century in highly esoteric fields—relativity, quantum and nuclear physics, astronomy and astrophysics. These scientific investigations led to an understanding of the source of energy within the stars, including our sun, and to fusion reaction.

Because of this basic science—and again many subsequent efforts—we may witness during the last third of this century a man made fusion reactor, the source of essentially unlimited energy upon which the future of civilization may well depend.

In my own experience, on a totally different scale, scientific study by many investigators of the firefly has resulted in a practical instrument for measuring pollution in our environment. In both instances, the fundamental work was motivated by scientific curiosity, while the practical results appeared later and in most instances, unpredictably.

Senator KENNEDY. As I understand you were one of those investigators?

Dr. McELROY. That is right.

We believe therefore that in the future the Foundation must support two major categories of scientific activity. First as I have already stressed, then we must continue and expand support of basic research in all of the fundamental disciplines. Such research, where the guiding principle is one of scientific opportunity, will inevitably provide the Foundation and the Nation, on a long term basis, with the knowledge and understanding underlying the formulation of valid remedies for society's problems.

Second, we believe the Foundation must reserve a modest though significant portion of its funds for projects of short range utility often of an *ad hoc* character but of valid scientific worth, directed to the problems society currently faces. I include in this category a broad range of activities extending from hailstorm prevention and earthquake engineering to the mathematical modeling of environmental systems—those of the natural environment, ecological systems, or society, and including the international biological program—all worthwhile science in themselves, but in addition, directly valuable to development of socially useful technology.

The Foundation has, of course, supported the two types of scientific activity over the years. The change in Foundation emphasis is rather one of formalizing and developing the short range relevant type of research, while continuing support of the long range or basic research. I note that much of the research currently being examined by Federal agencies for possible reduction of funding is the basic, long range type of research. It has been supported in the past because of the potential benefit accruing from such work. I believe that it is of the greatest importance for the Nation that these efforts continue, regardless of who supports them. For this reason since a significant decline in the magnitude of Federal support of any scientific research is inconsistent with maintaining the strength of the Nation, the Foundation will be fully receptive to proposals resulting from this enforced reappraisal. These proposals must compete, as I have noted, with all others on the basis of scientific merit.

One may cite many examples of limited Foundation support of work bearing on immediate problems, work contributing directly to meeting the goals of both the administration and the Congress. Thus the Foundation has sponsored research in such diverse fields as weather modification, oceanography and marine resources, sociological patterns in urban communities, and many others. These activities however, have usually resulted from unsolicited proposals received from the academic community. This is certainly proper, and the Foundation will continue to welcome the spontaneous inquiries of individual investigators. But work initiated in this way, which does not result from deliberate patterns of support, cannot be expected to lead to full or adequate coverage of a problem under investigation.

We believe, therefore, that an organizing principle is needed. Such a principle is available in the broad concept of Technology Assessment, as developed in the recent report of the National Academy of Sciences and which in its broadest sense may subsume many activities, including:

1. Appraisal of the overall effect of a current or potential technology on the natural or social environment. This aspect is most commonly associated with the term technology assessment.

2. The development of the methodological basis for making such appraisals, including studies of mathematical modeling and simulation, and research on methods of forecasting technological, environmental and social change.

3. The fundamental and applied research on the environment natural or social and including environmental monitoring, that must be conducted as a continuing process to support efforts at assessment.

4. The search for new technologies required for the solution of environmental or social problems, as well as the associated research necessary to conduct such a search. The work on weather modification by the Foundation over the past decade has been of this character.

We plan therefore to use this broad concept of Technology Assessment as an organizing principle to develop a substantial and coherent supplement to the traditional programs of the Foundation. Several comments in this connection are pertinent:

Such a program cannot be consummated within a single year. Although elements of the total activity have been undertaken in fiscal year 1970, the programmatic and conceptual arrangements required must be regarded as long range and forming a basic foundation for a continuing activity.

The field of opportunity I have described is virtually unlimited, and selection rules must be carefully developed at an early date to identify those areas of environmental and social concern where the Foundation can make significant contributions. Several planning efforts directed to this end have been undertaken by the Foundation, and results are under study by the senior staff.

Although in the past, the Foundation has been responsive almost exclusively to unsolicited proposals, the nature of this additional activity is such, I believe, as to require the active seeking of proposals wherever competence can be found—in universities, in industry, and in non-profit organizations and professional associations.

At this point, Mr. Chairman, I would like to introduce a word of caution concerning what the Foundation can do and what it cannot do. The foundation does not seek, nor can it normally exercise, an operating responsibility to carry out remedial programs. Rather the Foundation proposes:

1. To support research that will result in scientific information and interpretation useful to other Federal agencies with related statutory responsibilities. The Foundation intends of course to avoid duplication of effort, and I have personally initiated contacts with the heads of a number of Federal agencies to ensure that our plans are constructive and needed.

2. To provide available scientific knowledge to local institutions—regional, State and local. The State and local intergovernmental science policy planning program established in the Foundation will prove I believe, to be an important intermediary to help in meeting the objective.

3. To assist academic institutions to play a more important role in finding solutions to local problems.

I would like to note several specific items which I believe are properly considered a part of this new effort and for which we plan significantly expanded or modified support.

First, I wish to emphasize NSF support of the social sciences. Although it is our wish to increase support for these complex fields by about the same percentage as that for Research Project Support as a whole, this is by no means a measure of the total emphasis. Thus a large part of our new program Interdisciplinary Research Project Support as a whole, this is by no means a measure of the total emphasis. Thus a large part of our new program Interdisciplinary Research Relevant to Problems of Our Society or (IRPOS) will strongly reflect needs for research in the social sciences. We believe research in the area can provide new knowledge which can make a contribution to the solution of problems on a local, as well as at State and national levels.

For example, social science research already supported by the NSF may provide preliminary insights into ways of improving police and public relationships, such as what happens when a policeman first interacts with an individual or a group. For example, the tone of his voice, the expression on his face, are important factors in determining how the individual reacts to the policeman.

Another example is the educational environment as related to disadvantaged groups. Studies indicate that youngsters who had participated in the head start program moved along well in the first grade together with other students, yet they fell behind in the summertime because they did not continue to acquire knowledge at the rate acquired by youngsters of middle and higher income groups. Another study produced an interesting finding that all youngsters who come into school are treated equally by the teacher. The teachers expect them all to perform reasonably well. There are high expectations. When the young student, let's say, does not perform according to the teacher's standards, there is a psychological reaction which the teacher cannot apparently hide. It has a big impact on the youngster and gives him a psychological feeling of being inferior, which leads to further and further deterioration. Feeding back research results such as this to the education system could result in major improvements in the educational process.

Second, the IRPOS program was initiated only recently and the first grants will be made during fiscal year 1970. However, enormous interest has been generated by this program and a large number of inquiries and proposals have already been received. We believe that the IRPOS program will have a large impact on our understanding of social and environmental problems.

Senator KENNEDY. Would you tell me what is the magnitude of that program? I know you just are getting started with it.

Dr. McELROY. Approximately \$6 million this year.

Senator KENNEDY. Those were I think very useful examples which you gave us here on your testimony on page 7. Will you have for us perhaps some description of how those funds are being used in this program in some detail?

(The information subsequently supplied follows:)

HOW INTERDISCIPLINARY RESEARCH RELEVANT TO PROBLEMS OF OUR SOCIETY FUNDS WILL BE SPREAD

It is contemplated that support will be provided under the IRPOS Program for comprehensive projects organized around particular goals. The NSF Important Notice announcing the program stated that "arrangements involving coupling between different types of institutions, such as a collaboration between a university group and a group working in a federal laboratory or non-profit research center, will be encouraged when appropriate arrangements can be made. Involvement of individuals from outside the academic science community, including both the professions (law, medicine, etc.) and field practitioners, may also be particularly desirable in some instances." It was stated further that "funds will also be available for exploratory research and planning, and for supporting the growth and development of interdisciplinary groups that have not yet initiated a coherent program."

Since such a wide variety of proposals is being received, and since these are being competitively evaluated, it is not possible at this time to estimate how the program funds will be spread. The announcement stated that the principle criteria for selecting proposals for support will include: "significance of the problem being attacked, existing scientific capability, adequacy of organizational arrangements and research plan, institutional commitment, and the over-all scientific merit of the proposed program. Innovation and intellectual soundness will be stressed, with the development of related educational programs a secondary, though significant, matter."

Dr. McELROY. Yes, we will. Third we plan to reorient our institutional support for science program in a direction which will strongly recognize the needs of the social sciences.

Senator KENNEDY. Would you tell us what percent is now going into the social sciences and what percent you expect to go to the social sciences?

Dr. McELROY. In fiscal year 1969 in our institutional support it was a little over a million dollars; and in fiscal year 1970 we estimate a total of about \$2 million. We expect to increase that support to the order of \$5 million in fiscal year 1971. We do have, of course, the regular fundamental science support in social sciences in the research program itself, as well as a social science component in several of our other programs.

This reorientation will partially represent a response to the recent reports of the Special Commission on the Social Sciences and the joint report on the behavioral and social sciences of the Social Sciences Research Council and the National Academy of Sciences. In particular, we plan to combine into a single program our present university science development, department science development, and graduate science development, departmental science development, and graduate science facilities efforts. The resulting program will give us greater flexibility in funding university science development and will encourage institutions to respond more effectively to problems of society and the environment.

This support would be made available over a broad range, from the strengthening of existing departments in the social or environmental sciences (for their reorientation towards more useful social purpose), to the establishment of new types of multidisciplinary research centers and institutes to attack broad problems of society.

I would like to mention here that certain federally owned laboratories could well contribute to this effort, and I have already held

preliminary conversations with this end in view. You are also aware, I am sure, of the action by the House Authorization Committee with regard to the use of Federal laboratories.

Senator KENNEDY. Could you tell us where some of these laboratories are or a little bit about those arrangements?

Dr. McELROY. Yes. The one I am most immediately involved with is the Oak Ridge National Laboratory. Officials there have already initiated extensive studies in some of these societal problems. They have great capability across the board, engineering, scientists and so forth. They do need to add to their staff, however, economists and social scientists in general to shore up their activity.

There are other similar national laboratories: Brookhaven National Laboratory and the Argonne Laboratory is another.

Senator KENNEDY. Does Lincoln Lab in Cambridge lend itself to this?

Dr. McELROY. I think the present capability in Lincoln Laboratory in terms of manpower there would be limited in the environmental areas, but I understand they have great capability in other directions. I thought I saw something in the newspaper that Lincoln laboratory has been reoriented in a new direction but I do not have details.

Senator KENNEDY. This ties in to the efforts that have been made there by faculty members, students, trustees and others, to really consider the future of the Lincoln Labs. They come out with a strong recommendation that they try to move into some of these new areas of social concern. There is a great interest in that up there.

The House action certainly recognizes the desire of government owned or supported laboratories to get into some of these other fields.

Dr. McELROY. I have written letters to many of the Federal agencies, Senator Kennedy, to the effect that we would be very glad to support efforts in this direction and that we would welcome their contacting us whenever they thought appropriate.

Several other new programs, planned for initiation or expansion in fiscal year 1971, are particularly noteworthy:

On October 19, 1969, the International Decade of Ocean Exploration was announced, and the Foundation was assigned as lead agency responsibility for the United States share of this very significant program. Specific objectives of the program include scientific observations of the natural state of the ocean and its interactions with the coastal areas, improvement of environmental forecasting, seabed assessment activities permitting better management of ocean mineral exploration and exploitation, and a system to monitor oceanographic atmospheric conditions.

The Foundation was also assigned lead agency responsibilities for the Arctic research program. Beginning in fiscal year 1971 it will concentrate on scientific problems related to the Arctic including a major ecological study of the tundra regions, similar to those being undertaken under the international biological program.

We propose also a formalization of an earthquake engineering program, an expansion of work previously supported for several years to gain the knowledge needed for design and construction methods for buildings and other structures in earthquake zones.

Three directions in science education appear to me to have special importance and represent exciting opportunities for Foundation service to our society:

Man's culture and his social institutions and relationships are being increasingly shaped and conditioned by scientific and technological advance. At the same time man's perception of his environment, natural or social, and of the means by which he can successfully adapt to it, is becoming each day more and more complicated in a bewildering variety of ways. These circumstances place a heavy burden on the educational process to insure that all citizens, not only our future scientists and engineers, gain at least a basic understanding of science and its applications and confidence that inevitably accompanies deeper knowledge, and understanding. The Foundation, therefore, will place particular emphasis on the coming year on the development of science curricula and instructional materials to strengthen the average student's knowledge of science.

A second direction of unusual promise—combining education and research—is the support of student initiated and student managed, and student conducted research projects. This year the Foundation funded such an effort at a leading university and this project led to useful scientific information on lake pollution and more importantly to a constructive means for channeling the concern of our young people for their environment and their society. We anticipate the opportunity to support this type of program at many colleges and universities in fiscal year 1971.

Third, in fiscal year 1971, we wish to develop various types of educational curricula for highly trained technologists at all levels of higher education—from two year programs through masters and other kinds of intermediate degrees short of the doctorate. The term technologist is relatively new. We do not in our definition include skilled craftsman or technicians acquiring their skills through on the job training in industry or through traditional vocational courses in secondary schools. Rather our term technologist includes those who have received substantial training in specific fields of science and engineering and who can provide effective and much needed support, in industry as well as in the universities, to senior research and development personnel.

Notwithstanding the described changes for fiscal year 1971, I must report however, that we plan an overall reduction next year in Foundation support for science foundation. This is largely due to reductions in graduate traineeship support and secondary school teacher institutes. For the former, the reduction will not affect graduate students during the 1971-1972 academic year.

Senator KENNEDY. Just on this point here, could you tell us a little about the traineeship program and the fellowship program in terms of the kinds of individuals who are able to qualify for them?

Then I would like to ask you a few additional questions.

Dr. McELROY. The competitive fellowship program is designed to give an individual independence of movement and he competes with the best students in the country. Basically that program is available to anyone and a recipient may go to any graduate school he desires. The traineeship on the other hand gives the responsibility to the institution.

to develop programs and to attract the individuals they think most appropriate to their individual programs.

So, basically, they reach the same types of students except in one case the traineeship program leaves the initiative to the institution to go after individuals whereas under the competitive fellowships, the institutions respond to the requests of the students wishing to attend the given institutions.

Senator KENNEDY. Let me make two observations and get your reaction. First, as much as we like as many fellowship winners coming up to Massachusetts as we can have, doesn't the effect of this freedom of movement and latitude mean that fellowship students are going to cluster at the already pre-eminent universities and in the more established areas?

Dr. McELROY. Past experience indicates that this happens. As a matter of fact one of the main arguments for instituting the traineeship program was to prevent clustering at a few institutions.

Senator KENNEDY. What national interest or scientific interest necessitated a heavy or heavier reliance on these fellowship programs even in spite of that fact?

Dr. McELROY. I think the administration's position at this time is that they would prefer to look carefully into the entire mechanism of support of graduate students and particularly, as I understand it, look into the possibility of loans to individuals at the institutions.

This year we would study in detail the traineeship support relative to the loans or other and come back with additional recommendations the following year.

Senator KENNEDY. Did you increase student loans this year?

Dr. McELROY. We have no loan program at the National Science Foundation.

Senator KENNEDY. I meant the administration as a whole, are they increasing the loan program.

Dr. McELROY. I don't believe there is a specific program for graduate students.

Dr. HANDLER. There is an NDEA loan program; they have decreased their fellowships markedly but I don't know what is happening to their loan program.

Senator KENNEDY. Now doesn't the traineeship program have the additional advantage that the NSF can at least encourage or provide some leadership in certain directions of study and concern by granting traineeship programs to different institutions that are developing an expertise in particular areas?

Dr. McELROY. It allows the institution to be responsive. If an institution wishes to institute a program in training graduate students in science the traineeship program gives them the opportunity to advertise and effectively go out and seek students in that area without depending on chance.

Senator KENNEDY. I suppose the traineeship program also had the advantage of helping some students who perhaps are not as extraordinarily gifted academically as the fellowship winners but who show a firm sense of commitment to do research in certain areas in which solid research needs to be done.

Dr. McELROY. Yes, sir, the institution as a matter of fact, is free to use the funds to support any study that it thinks would be appropriate for a given program.

Senator KENNEDY. Do I understand that this area is at least somewhat unsettled in terms of the NSF position, in terms of where the emphasis and stress and priority ought to go between fellowships and traineeships?

Dr. McELROY. That is correct. We have made studies in recent years and we are now reexamining the entire question of graduate student support.

Senator KENNEDY. Dr. McElroy, I have to go to the opening of the Senate and we will have a very short recess and come back at five minutes after 11.

(Whereupon, at 10:45 a.m., a brief recess was taken.)

Senator KENNEDY. The subcommittee will come to order.

Senator Prouty.

Senator PROUTY. Thank you, Mr. Chairman.

Dr. McElroy, I am sorry I had to leave earlier but there were 25 Vermonters in my office, who arrived unexpectedly and there are times when we have to give precedence to our constituents even over science.

I have three questions I would like to ask you and then with permission of the chair submit several others which you could answer for the record.

Dr. McElroy, I would like to commend you now for your excellent stewardship of the Foundation. You have brought new life to the NSF. I commend you and welcome you to our subcommittee.

Both my bill, S. 3412 and the chairman's bill, S. 3700, authorize appropriations for the NSF for two years with dollar figures for fiscal year 1971 and open-ended authorizations for fiscal year 1972. Could you at this time supply this subcommittee a dollar figure for the fiscal year 1972 authorization?

Dr. McELROY. Senator Prouty, it is extremely difficult for us at this time to give a precise fiscal year 1972 figure for the reasons that we do not yet know what is going to happen with regard to other agencies and their support of basic science.

We certainly have thought about this question. Earlier we were talking something of the order of even up to \$800 million. That is one possibility. That figure, at this time, is a very tentative figure.

But this again will depend a great deal on what happens as a result of the Mansfield Amendment and what eventually happens within NASA, NIH, Department of Agriculture, etc., as Dr. Handler mentioned. So it is very difficult for us to give an informal opinion of what level will be required to maintain the support of basic science even at what one might call an essential level.

If I were to make a rough guess at this time it would be something in the order of \$800 million.

Senator PROUTY. As you are aware, I have been concerned about the geographical distribution of support for research and education in the sciences. Let me assure the chairman that I don't mind Boston being the hub of civilization, I am just trying to insure that the spokes reach out far enough.

Dr. McElroy, I know that you have done much in your brief tenure to improve the geographical distribution of support for research and education. I think the subcommittee would appreciate your describing what the Foundation is doing in regard to the geographical distribution of NSF support.

Dr. McELROY. As you know we have institutional support programs which attempt to support institutions essentially in every State of the Union, with either our institutional development programs or our departmental support programs.

And here we are extremely sensitive in attempting to develop what has been called additional centers of excellence throughout the United States. This we will continue as departmental support and as supplemental support to our initial development program.

In addition our people in the research support programs are sensitive to the importance of making sure that we support good young investigators throughout the United States and not have it localized in a few institutions.

At the present time we have roughly 220 Ph. D. granting institutions. In all of these institutions there are good young people that need support. It certainly would be our intent and it is the staff's intent to see that these institutions are continued with support.

We do have some special programs. The sea grant program is a good example. We have very good geographical distribution in the support of activities in that area. We are sensitive to this problem and we will continue to keep an eye on it to see that we have adequate centers of excellence and good geographical distribution of support.

Senator PROUTY. Public Law 91-120 requires that you shall keep the Committee on Labor and Public Welfare and the Committee on Science and Astronautics fully and currently informed with respect to all the activities of the National Science Foundation.

Has this provision in any way proved a burden to the Foundation?

Dr. McELROY. It is our purpose to keep the committee informed on activities that are of interest to you. We have not had any great difficulty that I know of in carrying this out. It is the administration's position, however, that provisions in law for explicit reports often prove to be burdensome and lose timeliness. As I say, in the past we have always tried to keep the committees well informed and we intend to continue to do that with or without a provision of law.

Senator PROUTY. I think I have just one more question. I believe Dr. Handler touched on it earlier. Are we producing too many Ph.D.'s? A reason frequently given for campus unrest is the fact that so many of our top professors are engaged in research projects at one time or another and the students seldom, if ever, see them.

Their courses are turned over to graduate students or others. Is this a problem? Is the responsibility of Federal Government to support Ph.D.'s perhaps as an employer of last resort?

Dr. McELROY. It is interesting that this question does seem to keep coming up and I have been asking around at a lot of places to see what the professors really do now. It was different, let us say, 30 years ago. Thirty years ago the professor was doing research and the graduate students were helping run the basic laboratories as they are now.

Fundamentally I see no great change in the participation between teaching and research. I would say over the years, however, we have seen extensive curriculum changes and on the surface it might have appeared that a professor's teaching time has gone down when in reality it is the other way.

Let me give an example. Twenty-five or thirty years back the department of biology might offer 50 to 100 courses in biology, very restrictive courses. There has been a revolution in curriculum in this country in the past 15 or 20 years which has brought in the CORE program wherein you bring your top-rate talent into a few key courses to give the student a broad perspective of biology, not a fragmented one. This has allowed the professor to spend less formal time lecturing but a lot more time interacting with the student in the laboratory, in seminars, and so forth. In my own case I think my participation in the educational process took more time rather than less. But if you looked on the box I was formally giving only one course a semester. And in previous years it had been a lot more. So I would say that—and there have been recent articles in *Science* supporting this—that our support of research has created a better atmosphere for education, and better trained students are now going into science than we have ever seen before in this country.

What we do need to do now, however, is to become more concerned with educating all our young people to the importance of science and how science can contribute to the future of this country, because 80 percent of them are not going to go into science in the sense that they become scientists, but they need to be intelligently informed citizens who understand the importance of science and technology.

Here I do not think we have done a good job. I think we do need curriculum reform along that line.

Dr. HANDLER. I endorse everything Dr. McElroy has just said.

I would like to add a few simple comments. It is clear from the quality of the preparation of the students who now enter graduate school and medical school, the two student groups I know best, that those arriving today are far better prepared to do so than their predecessors were a generation ago.

The educational process really has been successful despite all charges by students of irrelevance of their courses or "absenteeism," if you will on the part of professors.

In fact, to the extent that student unrest is justified by their failure to see professors, it is not because professors are doing anything different than they did years ago. It is the students who are different. They are different because they are better prepared. They arrive from high school into college with expectations concerning how much they will see and learn from the faculty which resemble those of graduate students when I made the transition from undergraduate to graduate school. In no small degree this is a testimonial to the success of NSF programs of course content improvement.

The problem is that we cannot afford what they are asking. The requirements for faculty manpower necessary if undergraduate students are to do what they now ask are decidedly greater than the country is prepared to fund.

But it is not due to absenteeism or changes in the behavior of the faculty. There may be exceptions, professors who are pursuing careers in the laboratory at the expense of seeing their students but, probably, there always were. We are simply more conscious of them at the moment. But, in the main, that is just not the real problem.

The real problem is the very high expectations of our student body, based on the fact that their previous preparation was so much better than what we knew. That is a problem the Nation has not faced up to at the present time.

Senator PROUTY. Mr. Chairman, I wonder if I could submit a series of questions which Dr. McElroy can reply to in the record?

Senator KENNEDY. They will be submitted.

(The material subsequently supplied follows:)

RESPONSE OF DR. WILLIAM D. McELROY, DIRECTOR, NATIONAL SCIENCE FOUNDATION TO QUESTIONS SUBMITTED BY SENATOR PROUTY

Question 1. For the past several years, the National Radio Astronomy Observatory has been very actively involved in the planning and design of a Very Large Array instrument, which we have been told was a very high priority requirement for the future advancement of radio astronomy. Your FY 1971 authorization and appropriation requests include no provision for this instrument. Has the project been abandoned, or what is the status?

Answer. The preliminary design and feasibility studies for the Very Large Array have been completed—the results of seven years of effort on the part of the technical staff at the National Radio Astronomy Observatory. The VLA's potential for detailed resolution of radio sources emitting immense quantities of energy and its capability to match optical resolution for all radio sources remain beyond those of any other radio telescope system yet designed. It now awaits authorization and funding to undertake prototype construction and initiate the first part of the array. Due to budget stringencies, a request for authorization and appropriations for the construction of the Very Large Array has been deferred until after FY 1971.

Question 2. There have been remarkable advances in the biological sciences in recent years. I understand that some of these developments may help us in our efforts to solve some of the pollution problems facing us. Could you tell us about some of the work being done to find biological solutions to the pollution to our rivers and lakes and about the work being done on bacteria treatment of solid waste products?

Answer. Recent advances in biological science provide a conceptual framework within which the effects of enrichment pollution of rivers and lakes may be controlled. Enrichment pollution is the addition to rivers and lakes of excessive amounts of inorganic plant nutrients, chiefly nitrate and phosphate, in the run-off from fertilized agricultural lands, and in the effluent from sewage plants. Such pollution results in an overgrowth of algae and rooted water plants.

A new approach to controlling the impairment of water quality by nutrient enrichment is suggested by recent ecological studies being conducted on the dynamics of the algae-animal plankton-fish food chain of lakes. Species of animal plankton differ in the effectiveness with which they remove algae from lake water. The most effective algae feeder in lakes is the crustacean *Daphnia*. It has been shown that when *Daphnia* predominate in ponds the water is more transparent than it is at times when other, smaller-sized, crustaceans predominate. These *Daphnia*, however, are also the favorite food for plankton-eating fish. The greater the concentration of plankton-eating fish, the smaller the population of large *Daphnia*, and the more the algae accumulate, thereby reducing the lake's transparency. Thus, manipulation of fish-stocks offers hope of managing a lake's ecosystem so that the overburden of algae can be reduced. Enrichment pollution fosters the growth of all algae, and quite naturally those kinds that cannot be utilized readily by the animal plankton in temperate lakes will tend to accumulate excessively. The shift to relatively greater abundance of blue-green algae than diatoms as a result of pollution is largely related to this effect. There are indications from current work that the presence of trace amounts of manganese prevents this shift in abundance from diatoms to blue-green algae. These investigations thus provide hope that the selective addition of certain chemical elements required in minute amounts for the growth of algae may shift the numerical dominance from unutilizable blue-green algae to kinds of algae that are readily eaten by animal plankton.

Should further research confirm and extend these findings, it may well be that the carefully timed addition to lakes of certain plant nutrients needed only in trace amounts, together with manipulation of the fish stocks will provide the basis for the control of lake transparency and provide a means of removing nitrogen and phosphorous from lakes in a form utilizable by man.

Before man's technological intervention, solid wastes were biological in origin and were recycled by largely biological methods. Basically, the treatment of sewage still depends upon a biological process of bacterial decomposition which is guided by our understanding of a normal process. However, we can now also recognize a problem which we are creating by ignoring an aspect of the normal cycle, which is the return of nutrients from this decomposition to the soil from which it originated. For the most part we have been depleting the land of nutrients which have had to be replaced with chemical fertilizers and have transferred the excess nutrients to lakes and rivers where they are not effectively utilized.

The largest components of plant waste material are cellulose and lignins which are largely decomposed to carbon dioxide by bacteria and fungi. Man's harvesting and cultivation of forests has, however, resulted in the concentration of cellulose in waste paper in the cities and lignins as a by-product wherever paper pulp is made. The natural process of decomposition is slow, but we do know that accelerated decomposition might be possible with the enzymes which organisms normally use in this process if we could obtain the enzymes in sufficient quantity. This approach is being studied currently.

Question 3. The Foundation is planning to expand its oceanography research activities in 1971. How many research vessels is the Foundation currently supporting and what is your estimate of the impact of these new oceanographic research activities on the operating support requirements for the research fleet?

Answer. The Foundation contributes to the support of 32 research vessels 50 feet or more in length, which are operated by 18 universities and private research institutions. In FY 1970 the Foundation provided 56 percent of the total operating costs of these vessels. The Office of Naval Research provided 34 percent and other federal and local sources provided the remaining 10 percent. The actual FY 1970 support for ship operations provided by the Foundation totaled \$7.47 million.

In addition, the Foundation owns and supports the operations of three vessels which serve special programs. These are the ELTANIN and HERO for the Antarctic Program and the UNDAUNTED for the National Sea Grant Programs. Expansion of Foundation support for oceanographic research in FY 1971 is not expected to affect these three vessels.

Exclusive of new funding which may be provided through the proposed International Decade of Ocean Exploration, the Foundation estimates that FY 1971 support for ship operations will be approximately \$7.5 million, or about the same as that for FY 1970. The increased demand for ship time anticipated by the new IDOE programs will increase the cost of ship operations. The request for support for the International Decade of Ocean Exploration is \$15 million in FY 71, of which it is estimated that approximately one-half will be used for the support of IDOE activities to be conducted by other agencies of the Federal Government and the remaining half for Foundation funded programs. At present the Foundation staff responsible for the IDOE is engaged in detailed planning of the specific programs and agencies to carry out IDOE work. The money budgeted for IDOE includes funds for ship support, possibly totaling as much as \$1.5 million in FY 1971.

Question 4. The International Decade of Ocean Exploration proposed will begin in fiscal year 1971. Would you tell us how this program ties in with your existing oceanographic research programs and what mechanisms you are going to use in providing for interagency coordination of the program? You state that about half of the \$15,000,000 requested for this program will be passed through money to other Federal agencies. Would you also tell us how you plan to manage the funding of other agency projects?

Answer. The National Science Foundation has been designated as the lead Federal agency for the International Decade of Ocean Exploration (IDOE). This program is oriented toward learning more about the ocean environment. It places new emphasis on standardized data collection and dissemination, expanded activity by a large number of nations, and stronger coordination among the various international bodies concerned with the sea. It will supplement certain IDOE-related programs already under way, such as the Cooperative Investigations of the Caribbean and Adjacent Regions (CICAR). By acceleration of certain objectives or change of emphasis the Decade will place special emphasis on:

1. Preserving the ocean environment by accelerating scientific observations of the natural state of the ocean and its interactions with the coastal margin—to provide a basis for (a) assessing and predicting man-induced and natural modifications of the character of the oceans; (b) identifying damaging or irreversible effects of waste disposal at sea; and (c) comprehending the interaction of various levels of marine life to permit steps to prevent depletion or extinction of valuable species as a result of man's activities;

2. Improve environmental forecasting to help reduce hazards to life and property and permit more efficient use of marine resources—by improving physical and mathematical models of the ocean and atmosphere which will provide the basis for increased accuracy, timeliness, and geographic precision of environmental forecasts;

3. Expanding seabed assessment activities to permit better management—domestically and internationally—of marine mineral exploration and exploitation by acquiring needed knowledge of seabed topography, structure, physical and dynamic properties, and resource potential, and to assist industry in planning more detailed investigations;

4. Developing an ocean monitoring system to facilitate prediction of oceanographic and atmospheric conditions—through design and deployment of oceanographic data buoys and other remote sensing platforms;

5. Improving worldwide data exchange through modernization and standardizing national and international marine data collection, processing, and distribution; and

6. Accelerating Decade planning to increase opportunities for international sharing of responsibilities and costs for ocean exploration, and to assure better use of exploration capabilities.

Interagency coordination of the program will be provided through the National Council on Marine Resources and Engineering Development and its Committee for Policy Review by an interagency panel chaired by NSF. This panel is already preparing a progress report on activities and accomplishments to date. Advice and guidance will also be received from an NSF Committee of university and industry representatives, yet to be established, and from the Committee on Oceanography of the National Academies of Sciences and Engineering. An Office for the International Decade of Ocean Exploration has already been established by NSF to carry out its responsibility as lead agency for IDOE. This Office is working closely with the staff of the Marine Sciences Council.

Funding of the IDOE programs of other Federal agencies will be developed from program proposals submitted to NSF by the individual agencies. There is no restriction on the number of agencies that may participate in the IDOE. Decisions as to pertinence to IDOE goals and objectives and priorities for funding, will be developed by NSF with the advice of the Marine Science Council and its Committee for Policy Review, and with guidance from the other bodies mentioned above.

Question 5. The Foundation plans to initiate a major hail experiment in northeast Colorado in 1971. Could you give us the background on this project? Tell us how many agencies are going to cooperate in the project and give us some indication of the number of institutions that will be involved and tell us what you hope to accomplish.

HISTORY OF PROJECT

Answer. In May 1965, the Interdepartmental Committee for Atmospheric Sciences (ICAS) of the Federal Council of Science and Technology requested the National Science Foundation to prepare a plan in cooperation with other Federal agencies, for a national program of research leading to the development of a technique for suppressing the formation of damaging hail from severe storms in the United States. The Foundation invited the National Center for Atmospheric Research (NCAR) to participate in the development of this plan, and in October 1965, NCAR organized the First National Symposium on Hail Suppression which was held in Dillon, Colo.

This conference resulted in the development of a broad outline of a national hail research program and the appointment of a National Hail Research Steering Committee under the chairmanship of Professor Verner Suomi of the University of Wisconsin to extend this broad outline into a full report suitable for submission to ICAS. During this conference, groundwork was laid for the implementation of a cooperative hail research field expedition during the summer of 1966 called "Project Hailswath" in which some 23 different research groups concentrated

their observational programs on hailstorms in the Rapid City, South Dakota area with the South Dakota School of Mines and Technology acting as host under Foundation sponsorship.

Based upon the experience of Project Hailswath in operating a large-scale cooperative field program, and with the appointment of 16 subcommittees to prepare specialized aspects of the overall plan, the National Hail Research Steering Committee completed its report in December 1967 and forwarded it to the Foundation for consideration. This was submitted to ICAS and in December 1968 ICAS endorsed the concept of an interagency approach to hail research through the establishment of a five-year field program of observation and test of cloud modification techniques at a single location. The Foundation was asked to prepare an operational plan, to determine where the observational site should be located, what resources were required, what roles the participating agencies should plan, and the estimated cost of the program over and above the normally programmed hail research activities of the various agencies involved. NCAR assembled this plan and, in April 1969, ICAS adopted the plan:

NSF was requested to assume the role of sponsoring agency. It was to establish the necessary management organization, and assist in the early identification of, and arrangements for, the necessary participation of other interested agencies in terms of facilities, manpower, and funding for FY 1970 and FY 1971.

DESCRIPTION OF PROJECT

The hail storm is one example of a severe storm which can be observed and forecast with the present state of knowledge of the atmospheric sciences and appears to be amendable to presently understood modification techniques. While not as damaging as the hurricane or tornado, its basic mechanisms are closely related to the more severe storms and if more completely understood, will probably provide the knowledge needed to approach the problem of hurricane and tornado suppression in the future.

Insurance statistics indicate current annual hail damage in the United States to be approximately \$300 million or more. Based upon results of hail suppression programs in other countries, it seems not unlikely that a reduction of from 30% to 50% in annual hail damage losses could be expected over a suitably protected area.

The plan proposed by the NCAR Select Planning Group establishes a single test area approximately 50 miles on a side of a region, such as Northeast Colorado, where hail is frequently observed during the summer months. This area is to be instrumented with ground radar for detection and analysis of storm systems and for control of aircraft engaged in project operations and observations. In addition, suitable rawinsonde facilities, lidar, ground meteorological observing networks, hail and rain-gauge networks, condensation and ice nuclei observing networks, and stereophotogrammetric facilities will be established.

Aircraft will be used to measure meteorological parameters at the boundaries of the storm system and will transmit data to a ground computer system for display in real time. An armoured aircraft will be available for penetration of the hail forming center of the storm to determine the location of hail, size of stones, liquid water content etc. The overall storm system will be monitored by a synchronous meteorological satellite. Precisely determined quantities of nucleating materials will be delivered with pinpoint precision by means of explosive rockets launched from aircraft into the liquid accumulation zone, or dropped into the storm-center from above. Infrared scanners and radiometers on aircraft will be used to detect and record the location and intensity of hail on the ground. Ground units equipped with hail collectors will obtain and preserve hail samples for later analysis. An Agricultural evaluation team is to be on hand to assess the impact of hail on crops, and an economics study team is to work closely with the project to work out systems of evaluation of results and to recommend ways to increase economic benefits.

The observations obtained from the field will be used to construct a dynamic mathematical model of a typical Great Plains hail storm from which studies can be made of the most effective means for modifying the storm to suppress the formation of damaging size hail. These modification techniques will then be tested under actual hail storm situations for the development of operational techniques to reduce hail damage losses.

It is expected that scientists from at least six universities and colleges will participate in the program.

FOUNDATION BUDGET SUPPORT

Support for the National Hail Experiment will be provided to NSF grantees at the universities and the National Center for Atmospheric Research.

Question 6. The physics research being done in the field of cryogenics indicates that we may be on the threshold of a major new technology which would have profound meaning for the nation's electric power industry. Would you give us your assessment of this research, and tell us what can be expected in this field?

Answer. Research in superconductivity has produced materials and an understanding of them which now allows the consideration of their use in technology. Several electric power companies are now exploring the economics and feasibility of power transmission over superconducting lines. A recent study indicates that existing state-of-the-art can make possible in the next decade, economical power transmission at the 100 million kilowatt level for distances longer than several hundred miles. The low transmission losses involved would make economical the construction of power plants with a capacity many times larger than is now practical. These could be located in very remote areas. A transcontinental superconducting power transmission facility of this type could also contain a small superconducting coaxial cable for communications purposes. Such a cable would have an information-carrying capacity far exceeding that of any presently available alternatives. The large superfluid helium production and transport capability associated with such a facility would make attractive the development of other low-temperature systems such as cryogenic computer memories.

The same materials, under consideration as superconducting power lines, are now being employed in an NSF supported project at Stanford University where a unique accelerator is being developed. The radio frequency superconducting cavities used in its construction are of niobium and as a result only one watt of power is required to accelerate particles at an energy gain of eight million volts per foot. By comparison, it takes one million watts of power using the conventional room temperature accelerator to achieve the same acceleration. The insulated cooling system which will surround the accelerating structure will contain about 5,000 gallons of superfluid helium and will be by far the largest ultra-low-temperature installation in operation anywhere in the world. The technology arising from this project will be very important for power transmission. In addition to making possible greater knowledge of the fundamental laws of physics, this new acceleration technique promises to be much less expensive than previous methods and raises the possibility of constructing a very intense, yet compact and relatively inexpensive, source of negative pi mesons. These mesons have superior properties for medical radiation therapy, and such a development could revolutionize this field.

Question 7. I am very much interested in the Foundation's plan to put together a special earthquake engineering effort in FY 1971. If I understand the situation correctly, this is one of those areas where a lot of people assumed that the government or industry or somebody was working on the development of economical design and construction methods for earthquake resistant structures; whereas in fact, this was not the case. Now the Foundation has decided to move into this area. What is involved here, and what are some of the results you expect to achieve from this new-effort?

Answer. It was initially thought that the necessary research in the field of earthquake engineering was being done somewhere, and perhaps funded by other agencies of Government. A careful search has disclosed, however, that much information is needed and that existing agencies do not have programs to acquire it. That is why the foundation has taken steps to initiate a special program described in our FY-71 Budget, which will enable us to establish a consistent series of grants for Earthquake Engineering Research.

The United States has been shaken many times by large earthquakes, with considerable loss of life and much property damage. The objectives of the Earthquake Engineering Program will be to find economical ways to construct earthquake-resistant buildings, dams, and bridges and to develop methods to prevent landslides. The Alaskan earthquake of 1964 caused five major landslides in Anchorage alone, as well as numerous soil failures along waterfront areas. The total damage resulting from these earth movements was over \$60,000,000.

Practically speaking, the field of earthquake engineering in the United States is 37 years old, dating from the 1933 Long Beach earthquake, and productive earthquake engineering research is very much younger. Although earthquake design requirements have now been added to some codes, they are not yet adequate to prevent severe damage or collapse of many structures. A Uniform Building Code,

having earthquake-resisting requirements, was used in designing buildings which were destroyed in the 1964 Alaska earthquake. Figure I shows the control tower at Anchorage Airport which collapsed during the earthquake. Figure II shows the Four Seasons Apartment Building in Anchorage following the earthquake. This new six-story building had just been completed and it had been constructed in strict compliance with the Building Code. Figure III shows a house that was destroyed in the Turnagin Heights slide area. These examples illustrate the need for improving our earthquake-engineering capability.

A major problem in the field of earthquake engineering is that engineers who must grapple with the problems of earthquake-resistant design have virtually no measurements available on the strong ground motions which occur during destructive earthquakes. To find solutions to earthquake engineering problems will require a greater knowledge of earthquakes and their effects on structures than we now have and we will need to develop more effective techniques of analysis and design than are currently in use.

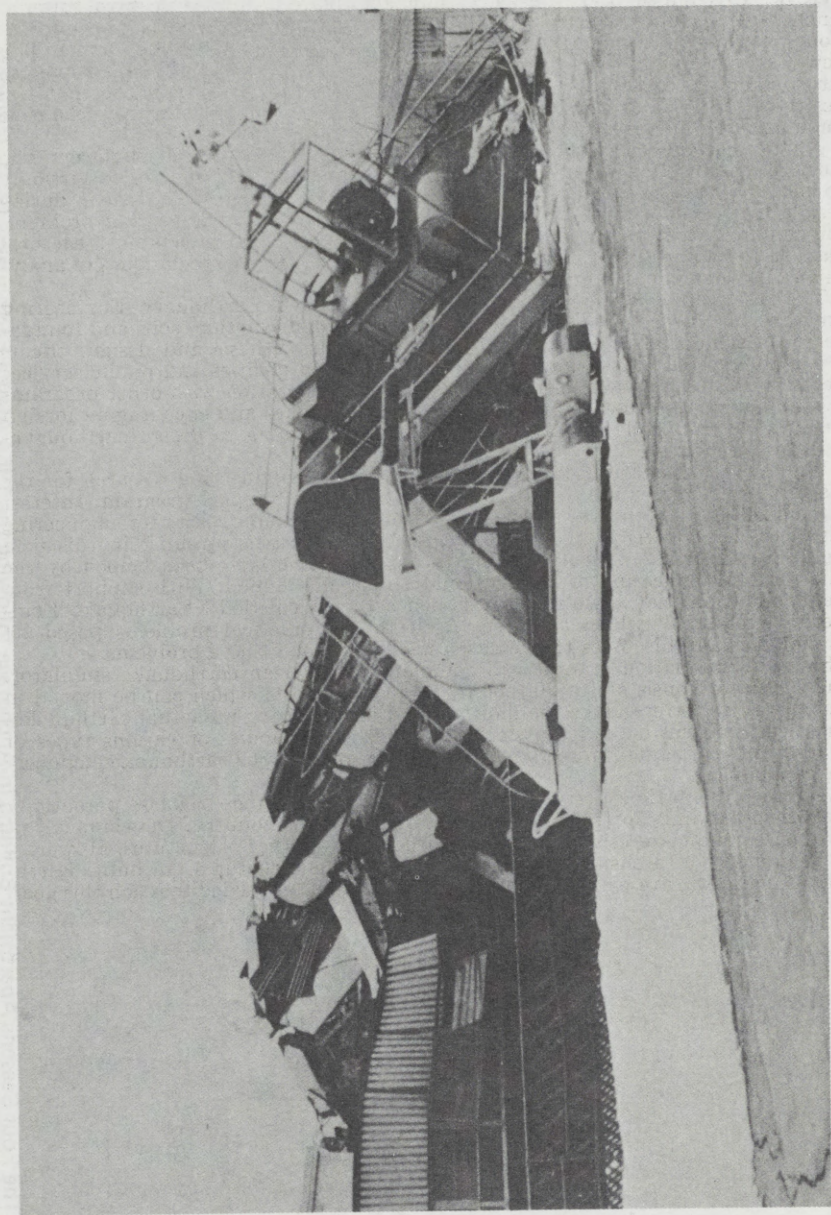
The research to be conducted under the proposed Earthquake Engineering Program includes investigations on problems of ground motion, soils and foundations; on structural dynamics analysis, structural synthesis and design; effects of earthquakes on coastal and inland waters, and on utilities and public services facilities. Post-earthquake inspection, as well as cooperation with other programs in studying the socio-economic aspects of earthquakes and encouraging foreign cooperation are vitally important to our goal of learning to design earthquake-resistant structures.

We have provided limited support to earthquake engineering research for the past few years under the Scientific Research Project Support program. Interest in the problem, as well as appreciation of the probable opportunity for engineering advances, has grown to the point where a special research effort in this field should be undertaken. In developing the program, we have been helped by the Division of Engineering of the National Research Council. With support from the Foundation they have recently issued a report entitled "Earthquake Engineering Research" which addresses itself to the practical problems posed by earthquakes and discusses the research needed to solve these problems.

Soon, a Foundation grantee will complete work on an earthquake simulator. The simulator consists of a 20 foot by 20 foot platform which can be moved in such a way as to reproduce the motions that occur during an actual earthquake. This new tool will make it possible to subject scale models of various types of structures to earthquake forces and will greatly enhance our earthquake engineering capability.

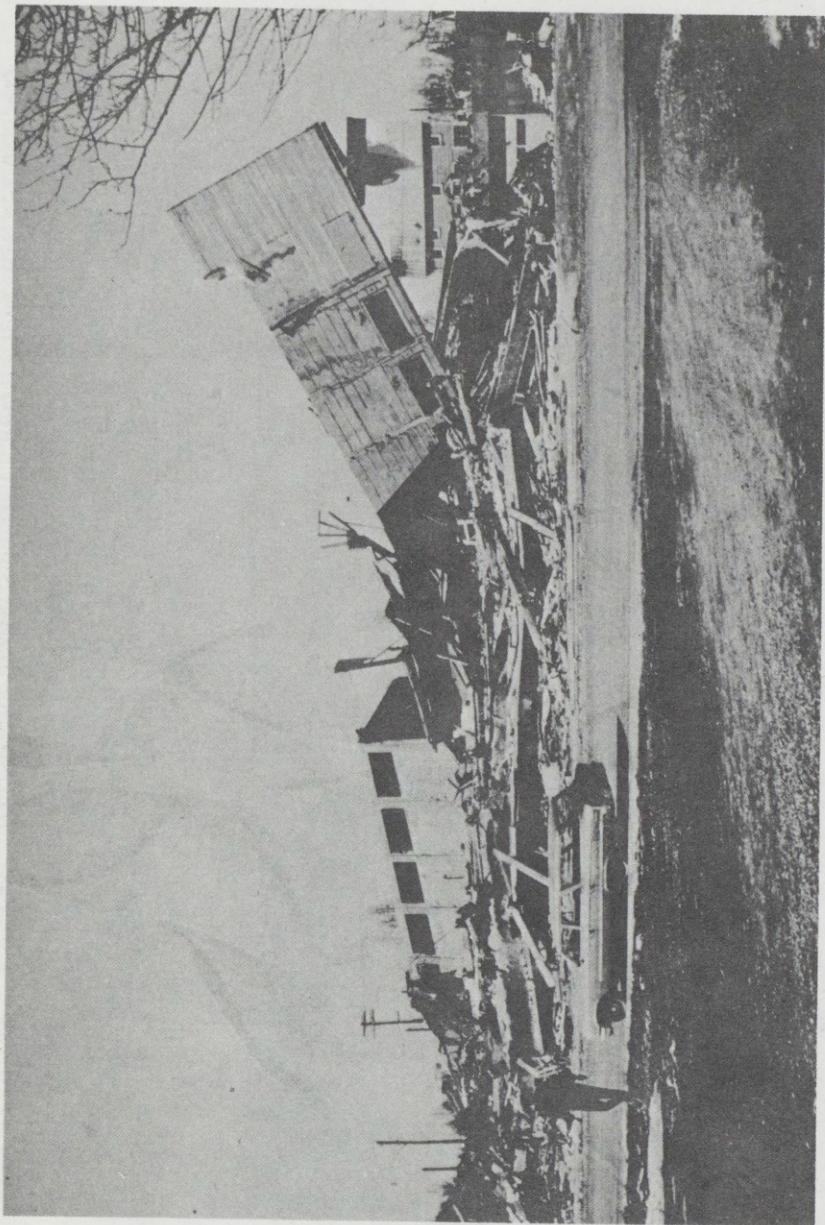
At the present time, it is estimated that there are some 200,000 potentially hazardous buildings in the more seismic regions of the country. Development of an ideal earthquake-resistant design will not change these structures. However, we should strive to ensure that no more hazardous structures are built. Earthquake Engineering research will provide the information needed to reach this goal.

Figure 1



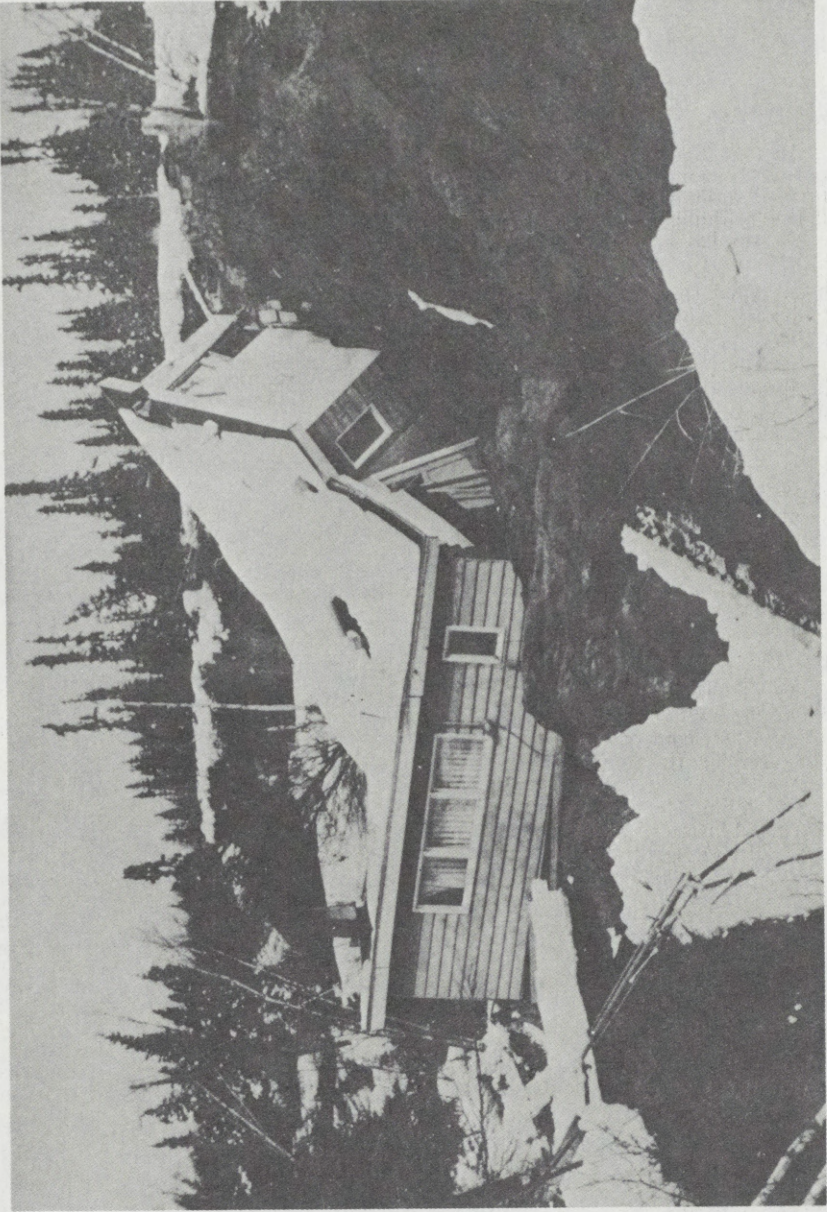
The Control Tower at Anchorage Airport which collapsed completely during the 1964 Alaska Earthquake.
(M. A. Sozen)

Figure II



The Four Seasons Apartment Building in Anchorage following the 1964 Alaska Earthquake. (P. C. Jennings)

Figure III



House damaged in Turnagain Heights slide area during Anchorage Alaska Earthquake of 1964. (G. W. Housner)

Question 8. Judging by the emphasis being given by the Foundation to the program of Interdisciplinary Research Relevant to the Problems of Our Society, Oceanography, Atmospheric Sciences and the Social Science it is obvious that you are making a bold effort to provide opportunities for the scientific community to contribute to the solutions of some of the pressing environmental and social problems facing us today. You have no doubt made adjustments in your organization to manage these new efforts such as the IDOC, Earthquake Engineering, etc. Would you tell us about your organizational capability for managing these efforts and how they complement your traditional programs?

Answer. The Foundation has made a number of organizational adjustments to provide a sound framework for the new program initiatives. These improvements may be summarized as follows:

(a) We have reorganized the major elements of the Foundation to reflect the establishment of the five statutory positions provided by Public Law 90-407. It is intended that these individuals, together with the Director, will play a key policy planning role and provide a continuing focus for program development and policy review within the Foundation.

(b) The Foundation's financial and administrative management activities have been consolidated into a new organizational grouping under the direction of an Assistant Director for Administration. The establishment of this non-statutory position stemmed from a special study of the Foundation by outside consultants from other Federal agencies and is intended to provide more effective staff support to NSF management.

(c) Major scientific programs with distinct managerial requirements have been placed in a new administrative group, National and International Programs, under the direction of one of the statutory Assistant Director positions. These programs include the National Sea Grant Program, the Polar Programs, International Scientific Cooperative Activities, Computing Activities in Education and Research, Science Information Activities, the National Research Centers and the International Decade of Ocean Exploration Program. Many of these programs are conceptually part of the new directions that the Foundation is planning to undertake.

(d) A new component, the Office of Interdisciplinary Research, has been established under the Assistant Director for Research to administer the IRPOS program. The establishment of a separate Office for this function reflects our heavy commitment to this important new initiative which already has generated enormous interest in the scientific community.

(e) The Division of Engineering played a major role in developing the concept of an Earthquake Engineering Program, drawing on its experience with research project support in this area. Accordingly, this Division, under the Assistant Director for Research, has been assigned the responsibility for implementation of the program.

(f) We have restructured our institutional support programs into two Divisions: the Division of Institutional Development and the Division of Institutional Resources, under the Assistant Director for Institutional Programs. Within this framework, we are combining the University Science Development, Departmental Science Development and Graduate Science Facilities efforts into a single program. The resulting program will give us greater flexibility in funding university science development and will encourage institutions to respond more effectively to problems of society and the environment.

(g) The immediate staff of the Office of the Director of the Foundation has been strengthened by the addition of several professional staff members to improve coordination of related programs such as those having to do with the environment.

Dr. McELROY. I have only a few more comments to make, Mr. Chairman. I am glad to answer any questions you might like. I would like to spend a moment discussing our studies with regard to teacher institute programs. Our studies show that in recent years the teacher institutes programs began to contain a much larger component of training specialists who would assist their schools in the adoption of new courses, materials and methods, rather than being devoted almost exclusively to teaching of science as such to the rank and file of teachers. Recently we have supported a few projects in which supervisors, principals, and other key administrators are trained to use the new materials, start new programs and do what is necessary for their

effective use by their schools. Our fiscal year 1971 program anticipates a relatively greater emphasis on this phase than in the past but it will be brought about largely by the continuing changes of earlier programs rather than by the unnecessary invention of new ones.

Our analyses of NSF teacher institutes disclose, that despite a constant turnover, a large percentage of the current high school science and mathematics teachers have attended at least one NSF institute, and we know, from some experimental projects, that it is quite possible to train some of them in a relatively short time to become local curriculum developers and implementers or at least get them started.

We plan, in fiscal year 1971, to begin to move more directly into this type of activity. Some of the teacher institutes, for example, will be used to train well-prepared teachers to develop and test their own curricular materials under expert scientific and educational supervision. At the end of such a training session the teachers will not only be able to take back to their schools their own good teaching units—with which they are emotionally identified and thoroughly familiar—but be reasonably competent to continue to become course developers within their own schools.

We will also expect to encourage and support colleges and universities in their preservice teacher education training programs to expose prospective teachers to the development and testing of instructional units. If this approach works, the capability of school systems to improve their own programs will have been increased substantially and their dependency upon outside resources, especially ones not precisely suited to their local needs, correspondingly reduced. In short, this phase is an attempt to see what can be done to develop in the schools themselves the capacity for improvement.

Senator KENNEDY. Doctor, what about the social sciences teachers? Do you intend to include them in these programs?

Dr. McELROY. Yes, sir, as a matter of fact there are curriculum reforms underway. We would certainly include those.

Senator KENNEDY. I was thinking of teachers institutes.

Dr. McELROY. I am not sure. May I call on Dr. Fontaine to tell us whether we have any summer institutes in social sciences.

Dr. FONTAINE. Social sciences are covered now in institute programs. They are covered, but there is one area that brings about some confusion in that we do not cover history.

Many people include history in the social science area. The social sciences are not as highly developed as we cover them in the high schools as is chemistry or physics, but they are very definitely there. We do offer a grading in those areas and we are devoting increased amounts of effort in the development of curriculum materials in these areas.

Senator KENNEDY. Stay with us, Doctor. As I understand there has been a reduction generally in the whole teacher institutes program, has there not?

Dr. McELROY. That is correct.

Senator KENNEDY. What has that reduction been? At least 40 percent, I think.

Dr. McELROY. Approximately. From about 36 to around 20.

Dr. FONTAINE. Reduction of \$16.4 million in the 1971 budget, \$16.4 million.

Senator KENNEDY. But you are still going to include social sciences teachers in your program for institutes in the summer?

Dr. FONTAINE. That is right. They are already included.

Senator KENNEDY. Will this be the first summer program when they have been included or have you included them in the past?

Dr. FONTAINE. They have been included in previous years.

Senator KENNEDY. How would the number of social science teachers at institutes vary in the period of the last couple of years?

Dr. FONTAINE. I would have to supply that for the record.

Senator KENNEDY. If you could for perhaps the last two or three years, and include as well the numbers of science and mathematics teachers.

(The information subsequently supplied follows:)

NATIONAL SCIENCE FOUNDATION SUPPORT FOR SOCIAL SCIENCES—PRECOLLEGE EDUCATION IN SCIENCE,
FISCAL YEARS 1968-70

[Expressed as fraction: $\frac{\text{Social sciences}}{\text{Entire program (all science disciplines)}}$]

	1968	1969	1970
Student development			
Proposals received.....	12/227=5.3%	8/251=3.2%	18/278=6.5%
Proposals granted.....	8/139=5.8%	6/112=5.4%	7/111=6.3%
Dollars granted (in thousands).....	\$100/\$2,081=4.8%	97/1,816=5.3%	101/1,819=5.6%
Participants.....	260/6,131=4.2%	243/5,850=4.2%	247/4,939=5.0%
Instructional personnel development¹			
Proposals received.....	44/1,118=4.0%	38/1,160=3.3%	80/1,229=6.5%
Proposals granted.....	28/811=3.5%	23/773=3.0%	53/838=6.3%
Dollars granted (in thousands).....	\$934/\$36,496=3.1%	\$727/\$33,365=2.2%	\$1,575/\$35,719=6.4%
Participants.....	846/35,082=2.4%	800/32,152=2.5%	1,852/36,094=5.1%
Instructional program development—Implementation activities²			
Proposals received.....	22/281=7.8%	20/341=5.9%	30/376=8.0%
Proposals granted.....	11/107=10.3%	18/175=10.3%	20/186=10.8%
Dollars granted (in thousands).....	\$308/\$4,423=7.0%	\$819/\$6,998=11.7%	\$860/\$6,706=12.8%
Participants.....	286/5,245=5.6%	573/8,135=7.0%	495/8,448=5.9%
Development of educational materials³			
Proposals granted.....	11/48=22.9%	6/29=20.7%	6/26=23.1%
Dollars granted (in thousands).....	\$2,454/\$12,217=20.1%	\$1,536/\$6,229=24.7%	\$1,394/\$4,494=31.0%

¹ Includes all institute programs, summer, inservice and academic year, plus conferences.

² Includes cooperative college-school science program and conferences for the training of resource personnel.

³ Includes course content development phases only.

Dr. FONTAINE. One comment would be helpful here perhaps. In our education programs—across all programs—the contribution towards social sciences is about 10 percent of the total science education budget.

Senator KENNEDY. Let me ask you, Doctor, isn't it true that in many of the high schools themselves the history courses are broad courses which include the social sciences such as economics or political science.

Dr. FONTAINE. There is no uniformity in this particular area. History does deal with some of the aspects of the social sciences. We have an even larger problem area in the case of social studies which are not social sciences as presently defined by the National Science Foundation. However we say that if a high school teacher is teaching history and has been assigned to teach a science course the next year, he is eligible to apply to attend an institute in the field he is to teach.

It is a difficult area for us to sort out. But we are trying to be as helpful as we can within what we consider our legislative mandate.

Senator KENNEDY. Thank you very much.

Dr. McELROY. We consider these changes in our education program to be extremely important. I am sure you recall that in the years since Sputnik we have substantially improved curricula in science and mathematics. These changes, however, were originally and rightfully aimed at the upper twenty percent of our students with the ability to go into these fields professionally. Now, we feel it is time to broaden our efforts to improve the curricula for the great mass—the other 80 percent—who will use science and mathematics or be affected by it but not necessarily in a professional way.

It is also important that our colleges and universities address themselves to this problem.

In summary, we view fiscal year 1971 as a period of transition to new directions or areas of emphasis in our science education programs.

There is one separate item I wish to bring to your attention—the planned resurfacing of the antenna at the Arecibo Observatory in Puerto Rico which presents some very complex engineering problems.

Preliminary engineering studies and cost estimates indicate that a perforated lightweight aluminum material, 0.008-inch thick, could be used to resurface the antenna, at a cost of approximately \$3.8 million. However, a more detailed review of these preliminary studies and cost estimates has raised a number of questions concerning problems related to the installation of the proposed surface. Additional data are also needed to determine the durability of the aluminum material proposed for the resurfacing and to insure that proper allowances have been made for wind stress, heat effects, et cetera.

In view of these developments, the Foundation now proposes to proceed to obtain immediately much more detailed engineering studies, from which we can determine the most suitable type of resurfacing material and more precise estimates of all costs involved. These studies will also establish that the material and design selected will maintain the necessary tolerances so that the new surface will meet the desired performance requirements. Therefore, we propose to utilize fiscal year 1970 funds to cover the costs of these engineering studies. If these studies show that the estimate of \$3.8 million is not correct, we will review the findings with the appropriate Congressional committees before proceeding with the project.

Finally I would like to mention briefly several organizational effectors and improvements being made to implement the Foundation's new efforts. The following changes are in progress:

1. Public Law 90-407 provided for the establishment of five statutory positions—a deputy director and four assistant directors. We have reorganized to reflect this change. The President has just announced four of these nominations and Senate confirmation is now pending. These individuals together with the Director, will form a coherent policy planning group within the Foundation, one serving as a continuing focus for program development and policy review.

2. During fiscal year 1969 a special study was made of the administrative operations of the Foundation by outside consultants from other Federal agencies. As a result, a new nonstatutory position of Assistant Director for Administration was established to ensure a more streamlined and effective management support structure.

3. Major scientific programs with distinct managerial requirements have been placed in a new administrative group, national and international programs. These programs include the national sea grant program, the polar programs, International Scientific Cooperative Activities, computing activities in education and research, science information activities, the national research centers, and the International Decade of Ocean Exploration Program. Many of these programs are conceptually part of the new directions that the Foundation is planning to undertake.

4. The establishment of an Office of Interdisciplinary Research, under the Assistant Director for Research, to administer the IRPOS program, began in the current fiscal year.

Mr. Chairman, it has been a pleasure to discuss the reoriented thrust and new efforts that the Foundation has included in its total program for fiscal year 1971. Implementation will require our best efforts and the close cooperation of the academic and research community. But we know success can pay enormous dividends as we move into this critical decade and beyond.

You will note from the table attached that we are requesting \$498 million to be authorized by this committee plus \$2 million in excess foreign currencies. In addition, \$13 million is requested for the sea grant program—to be separately authorized—for a total of \$513 million which we firmly believe can be used effectively and wisely.

Although, Mr. Chairman, our request is an increase over fiscal year 1970, the inclusion of several specific items, such as the International Decade of Ocean Exploration and funds earmarked for anticipated proposal pressure, means that our planned program will barely maintain the level of effort of the current fiscal year.

(The information referred to follows:)

**NATIONAL SCIENCE FOUNDATION
RECONCILIATION OF AUTHORIZATION AND
APPROPRIATION REQUESTS FOR FISCAL YEAR 1971**
(In millions of dollars)

	Authorization To be Author- ized under Public Law 81-507, as amended	To be Author- ized under Public Law 89-688, as amended	Appropriation Requested
Salaries and Expenses Appropriation:			
Support of Scientific Research.....	\$292.0	—	\$292.0
National Sea Grant Program.....	—	\$13.0	13.0
Computing Activities in Education and Research.....	15.0	—	15.0
Science Information Activities.....	13.0	—	13.0
International Cooperative Scientific Activities.....	2.2	—	2.2
Institutional Support for Science.....	55.5	—	55.5
Science Education Support.....	96.9	—	96.9
Planning and Policy Studies.....	2.9	—	2.9
Program Development and Management.....	20.5	—	20.5
Salaries and Expenses Appropriation, Subtotal.....	498.0	13.0	511.0
Scientific Activities (Special Foreign Currency) Appropriation.....	2.0	—	2.0
TOTAL, NSF.....	500.0	13.0	513.0

Senator KENNEDY. Thank you very much, Dr. McElroy. You had a very helpful and useful statement.

I will ask either of you distinguished gentlemen to respond to these questions. First, could you tell us about the State and local inter-governmental science policy planning program?

We had a meeting recently up in New England sponsored by this program which I had the good fortune to attend. Could you tell us a little about what has been happening with that program, what success, what interest by the local groups?

Dr. McELROY. There is a great deal of interest here. As you know, this is administered out of Dr. Falk's program by Dr. Frank Hersman. At the present time the Office of Science and Technology in a group chaired by Eric Ward has been visiting 10 universities or 10 States, I should say, and have been interacting with the States to determine how we can be helpful in Federal-State relationships.

I have participated on several occasions in these programs in Pennsylvania and in the Rocky Mountain States. I met recently with a group of five governors and I can assure you that there is a great deal of interest in trying to get good science and technology into the planning process in these States.

Senator KENNEDY. How important is that program, do you think, in terms of enabling these communities to attempt to meet unmet needs?

Do you find a cross fertilization of ideas both in terms of local groups having better understanding of the direction of the Foundation and also the Foundation knowing some of the legitimate interests and concerns of local government?

Dr. McELROY. I think there is no question that this is an extremely important program.

The Foundation and its staff have much to contribute to helping the local governments understand the importance of science and technology in the planning process. I met with the Governor of Maryland recently and talked with him about reactors in the Chesapeake. With better input from science one could have anticipated some of the problems there. A careful study would have eliminated some of the conflicts on what should have been done. I think this is extremely important.

I think Dr. Hersman and Dr. Falk and his group have much to contribute here as they gather experience in passing on information to the States. I think it is extremely important.

Senator KENNEDY. As you know, the Department of Commerce has cancelled its State technical service activity. Do you think it would be possible for the Foundation to prepare the format for another program of this type which would permit various mission-oriented agencies at every level of government to make better use of science and technology?

I have a letter here from Senator Randolph of West Virginia, who talks about the Commerce Department program and his very great concern that the program was dropped.

I think he is particularly interested in the impact on small business groups.

Dr. McELROY. I think the small business matter is a slightly different problem. I think it would be a mistake for the Foundation to get involved with business in terms of management problems.

We can, however, under the concepts of our program interact with the governors of States and with their science advisers and help them do many of the things that were formerly carried out under the Commerce program. I think it would be very difficult for the Foundation to get into the support, in effect, of small business in that type of management problem.

That would be something that would be a policy matter that I would have to take up with the National Science Board before I could indicate a firm negative or positive position.

Senator KENNEDY. I suppose that even though you could not provide direct kinds of assistance to small business—it is still possible for you to create a program which other agencies could participate in.

Dr. McELROY. We could work with the States and other Federal agencies, yes, sir.

Senator KENNEDY. With respect to the college science improvement program, I think most of us probably remember from our college days that many of the students who start in on science or scientific subjects switched over to other courses of study.

One of the obvious reasons was the complexity of physics and chemistry and biology, and the difficulty of preparing materials and developing the courses. I was wondering what role does the improvement program play in terms of developing new teaching techniques or methods of instruction in addition to curriculum changes.

Dr. McELROY. It plays a very large role in developing new techniques and approaches. As I indicated before it is our intent and hope to get the cooperation of colleges and universities, even to the point of helping out high schools, in getting a science program developed that would be more appropriate to nonscience majors. This is where one of our difficulties has arisen. I think we are in good shape, for science-oriented students. We think we need do a better job with non-science-oriented students. It is through the cooperative program that we hope to make some deeper thrusts.

Senator KENNEDY. How much was obligated for the college improvement program in fiscal 1969?

Dr. McELROY. Could I ask Dr. Fontaine to answer that?

Dr. FONTAINE. \$8.7 million.

Senator KENNEDY. How much is authorized in the present budget?

Dr. FONTAINE. \$4 million is the amount in the budget. The House authorization committee I believe increased it to \$8 million.

Senator KENNEDY. How much of a demand do you have for those programs now in terms of application? If you know, fine. If you want to submit it later, you may.

Dr. FONTAINE. Mr. Chairman, I have information on the current year only before me now. We will provide complete information for the record.

(The information referred to follows:)

THE COLLEGE SCIENCE IMPROVEMENT PROGRAM (COSIP) CONSISTS OF THREE SEPARATE COMPONENTS

COSIP A; INDIVIDUAL INSTITUTION PROJECTS

From its initiation in fiscal year 1967 through April 9, 1970, the program had received 292 proposals requesting a total of approximately \$57 million. It is estimated that by June 30, 1970—the end of fiscal year 1970—some 15 additional proposals, requesting approximately \$2.9 million, will be received, so that the total for the first 4 years is projected to be 307 proposals, requesting very nearly \$60,000,000.

The program had, by April 9, 1970, made 121 grants; these, together with the estimated 10 grants which will be made before the end of fiscal year 1970, will result in a total of 131 active grants, with a total funding of about \$23.6 million. By the end of fiscal year 1970, 99 proposals will have been denied, and 41 will have been withdrawn or transferred to another program. Thus of the 307 proposals before the program in its first four fiscal years of operation, action has been (or will have been) taken on 271, and some 35 proposals, requesting a total of approximately \$6.8 million, will be carried over into fiscal year 1971.

COSIP B; INTERINSTITUTIONAL PROJECTS IN 4-YEAR COLLEGES

The activities of COSIP B, which provide support for cooperative activities of associations of 4-year colleges, were initiated in fiscal year 1969. In the two years of its operation, the program has received a total of 36 proposals, requesting funds amounting to \$6.43 million. Of the 36 proposals, 21 have been (or will have been) supported by grants totalling \$1.83 million. Three proposals have been withdrawn, 8 will have been denied, and two will be carried over into fiscal year 1971. These two proposals request a total of \$400,000.

COSIP C; COOPERATIVE PROJECTS FOR 2-YEAR COLLEGES

This segment of the program, similar in character to COSIP B but directed toward strengthening of science education programs in junior colleges—the fastest growing segment of higher education in the United States—was initiated simultaneously with COSIP B, thus it also has been active for two years. Operating on one proposal closing date per year, with grants made on May 1, the program completes its action on proposals received in any one fiscal year; there is, therefore, no question of proposals being carried over to a subsequent fiscal year. Data for fiscal years 1969 and 1970 are as follows:

	Number of proposals		Funds	
	Received	Granted	Requested	Granted
Fiscal year 1969.....	46	31	\$4,244,400	\$1,980,900
Fiscal year 1970.....	27	10	2,325,700	680,800
Total.....	73	41	6,570,100	2,661,700

Totals, then, for 4 years of COSIP operation, are these:

	Proposals		Funds (millions)	
	Received	Granted	Requested	Granted
COSIP A.....	307	131	\$60.0	\$23.6
COSIP B.....	36	21	6.43	1.83
COSIP C.....	73	41	6.57	2.66
Total.....	416	193	73.00	28.09
Reducing the totals by carryover to fiscal year 1971.....	37		7.2	
Total, on actions taken in 1st 4 years.....	379	193	70.8	28.09
Percent supported.....		50.8		39.6

Senator KENNEDY. I think if you could give to us the kinds of requests, including some of those that have been turned down, it would be useful for us. I don't know how readily available or how voluminous the preparation of such material would be. But I think it would be useful for us to at least have some idea as to the kind of requests that are not able to be funded because of the limitation on resources.

Dr. FONTAINE. Actually, there is not a great deal of difference in the kinds of activity proposed by proposers who are successful and proposers to whom we deny support; there is a difference, clearly, in the quality of what they propose to do. The quality difference may come from lack of capability within the institution to carry out what is proposed, from hastily prepared proposals that demonstrate failure of the institution to look objectively at itself and to assess its own strengths and weaknesses, et cetera. In COSIP B and COSIP C, in which only some 27 percent of the funds requested have been granted, we have had to deny many proposals judged meritorious and fully worthy of support. In COSIP A, because of the open nature of proposal receipt and grant dates, we have in some cases avoided denying proposals for which funds were not available by carrying proposals into the subsequent fiscal year. We have, however, denied others when we felt strongly that, although the plan presented was not sufficiently strong to merit immediate support, the institutional capability was there, and needed only further institutional self-study, with assistance of some outside consultation, to develop a plan fully worthy of support. The National Science Board has approved, with implementation to be authorized if program funding warrants it, a plan to offer to those institutions whose proposals must be denied, but which are seen to be capable with minimum help to develop a sound plan, modest grants to assist in further institutional self-study.

Senator KENNEDY. What do you expect next year? Can you make any estimate?

Dr. FONTAINE. I think we can make a pretty good estimate for COSIP A, and reasonable estimates for COSIP B and C. I estimate the total requirements would be on the order of \$10-12 million. I will provide the details for the record.

(The information referred to follows)

ESTIMATED COST OF COLLEGE SCIENCE IMPROVEMENT PROGRAM FOR 1971

COSIP A: Individual Institution Projects. It is only rarely that a proposal to the COSIP A program can be acted upon in less than 6 months. Therefore, to estimate the requests to be faced by the program in fiscal year 1971, we shall consider here, from *new* proposals expected in fiscal year 1971, only those to be received in the first 6 months of that year. Looking at program history, and taking into account month-to-month variations in proposal receipt, we estimate that approximately 25 new proposals, requesting very nearly \$5.0 million, will be received. Furthermore, between the present and December 31, 1970, current projects at 17 institutions will terminate. Three of these institutions have already submitted proposals for renewal (not for those departments already involved, but in large measure turning to other departments, with more attention to social sciences than was evident in first-round proposals); at least 12 of the remaining 14 institutions can be expected to request continuing support, with a total additional request amounting to about \$2.4 million—and these we can expect, from the experience and known capability of the proposers, to be almost fully fundable.

What COSIP appears to be facing, therefore, for fiscal year 1971 funding, is a total request in the Individual Institutions component (COSIP A) made up as follows:

	Proposals	Funds requested (millions)
Carryover from fiscal year 1970.....	35	\$6.8
New proposals expected in first 6 months of fiscal year 1971.....	25	5.0
Total requests excluding renewals.....	60	11.8
Renewal proposals.....	12	2.4
Totals (COSIP A).....	72	14.2

It is clear that funds now requested for COSIP operations for fiscal year 1971 will not permit the program to continue its past pattern of operations. Because of its start late in the year of initial operations, and hence a relatively large backlog of proposals carried over to the second year—and extension of this practice to years three and four—the program has been able, by carrying meritorious proposals over to the next funding year, to support a large percentage (roughly 85%) of the proposals judged to merit support, and to provide, in the case of those supported, the full three years of support. With \$23.6 million in grants, based on a request of about \$60 million, the program has responded positively at a level of about 40% of the requested level. Maintenance of this level on new requests would call for about 40% of \$11.8 million (or \$4.70 million) plus the amount needed for the 12 renewals at \$2.40 million—a total of \$7.10 million for COSIP A alone.

COSIP B: Interinstitutional Projects in 4-year colleges. There is every reason to believe that the growth shown in the first two years of operation will continue in fiscal year 1971, leading to an estimate of at least 30 to 35 proposals with a total request of not less than \$6 million. Adding to this the 2 proposals carried forward leads to a total COSIP B request of \$6.4 million. Merely to respond, as the program did in its first two years, at the 30% level would require almost \$2 million; this would be providing support to roughly *half* of the fully meritorious proposals—a distressing situation to those associations that go unsupported despite their fully meritorious plans. The program would like, obviously, to go at least half way—a requirement of \$3.1 million.

COSIP C: Cooperative Projects for 2-year colleges. It is difficult to predict activity that may be expected in connection with cooperative projects for 2-year colleges, though recent conferences with junior college personnel, and with representatives of 4-year colleges who report many requests coming to them from nearby junior colleges, lead us to believe that the drop in requests received by the program in its second year of operation will show a marked reversal in fiscal year 1971. With the great need for strengthening the science education programs of these junior colleges, and considering the effect that this program is having on the 464 departments now engaged in cooperative efforts with COSIP C support, the program should be in a position to respond favorably to a much larger fraction of the meritorious proposals than it was able to support in fiscal year 1970, when some 75% of the proposals were worthy of support, but only 37% actually received support. Our best estimate of the request for fiscal year 1971 is \$3,500,000; to support this program at the 50% level would require \$1.75 million.

COSIP: Estimate of Total Requirements in fiscal year 1971.

In summary, based on above estimates that would permit *reasonable* response (by no means full response) to meritorious COSIP proposals would require:

	[In millions]
COSIP A.....	\$7.10
COSIP B.....	3.10
COSIP C.....	1.75
	11.95

This will clearly be impossible with the \$4 million in funds requested in the budget; the program will be forced to make hard choices—not only hard choices among the three components of COSIP, each of which is providing much-needed support to a particular group within its present broad target of “predominately undergraduate institutions,” but it will also be forced to defer program plans—approved by the National Science Board in March 1970 and to be initiated at the discretion of the Director—to open the program to undergraduate departments which, by the accident of their being part of an institution which, in some discipline other than their own grants more than 3 Ph.D.’s per year, are now ruled ineligible to participate in the COSIP program. These departments, predominately under-

graduate in their own operations, are in many cases more in need of assistance—their programs more in need of real improvements—than departments in institutions which have no graduate programs.

Senator KENNEDY. Senator Pell has been here now for some time. Just before he gets started, what I would like to do, Dr. McElroy and Dr. Handler, is get from you, with respect to all your programs, the number of applications of worthy candidates and the resources it would take to grant these applications, and balance this against existing resources which are available to the National Science Foundation. I would like to do it with the fellowship program, the traineeship program, the college improvement program, the teacher institute program and so on.

I would also appreciate the views of the Agency on the value of continuing the \$50 on \$60 million worth of projects which are being dropped by other agencies.

Also, how much of that \$10 million allocated to cover dropped projects would have been used for new research by younger scientists if you did not have to spread it over to cover the mission-oriented agency's dropouts?

Dr. McELROY. We will compile the information and submit it for the record.

(The information subsequently supplied follows:)

National Science Foundation graduate fellowship program, fiscal year 1970

Applications received.....	8, 200
Applications judged worthy of NSF support.....	4, 141
Estimated cost (millions).....	\$20. 7
Funds available (millions).....	\$11. 1
Actual awards.....	2, 220

Fiscal year 1971

Estimated number of applicants.....	9, 000
Estimated number worthy of NSF support.....	4, 500
Estimated cost (millions).....	\$22. 8
Funds included in fiscal year 1971 budget (millions).....	\$12. 7
Estimated number of actual awards.....	2, 530

National Science Foundation graduate traineeship program, fiscal year 1970

Requests received:	
9- or 12-month traineeships.....	17, 510
Summer traineeship for:	
Graduate teaching assistants.....	8, 737
Number of separate institutions.....	224
Number of separate science departments.....	3, 354
Estimated cost of requests (millions).....	\$99. 9
Funds available (millions).....	\$28. 1
Actual awards:	
9- or 12-month traineeships.....	5, 123
Summer traineeship for graduate teaching assistants.....	938

Fiscal year 1971

Estimated requests:	
9- or 12-month traineeships.....	¹ 19, 300
Summer traineeships for graduate teaching assistants.....	9, 600
Estimated cost of requests (millions).....	\$110. 2
Funds included in fiscal year 1971 budget request (millions).....	18. 7
Estimated number of awards:	
9- or 12-month traineeships (continuations only).....	² 3, 322
Summer traineeships for graduate teaching assistants.....	940

¹ Estimated number of new traineeships were offered.

² Continuation only are provided for in the fiscal year 1971 budget request.

REDUCTION OF ACADEMIC RESEARCH SUPPORT BY FEDERAL AGENCIES OTHER THAN THE NATIONAL SCIENCE FOUNDATION

The best estimate currently available concerning the proposal pressure which the National Science Foundation must anticipate in fiscal year 1971 as a result of reductions in the support of academic research by other agencies is given in the following table:

[In millions of dollars]

	Amounts based on firm information	Additional amounts based on uncertain information
Department of Defense:		
Air Force.....	7.7	8.3
Navy.....	2.8	.3
Army.....	1.0	1.1
ARPA.....	.5	1.4
Subtotal.....	12.0	11.1
NASA:		
Sustaining university program.....	7.0	
Traineeships.....	4.2	
Other research.....	15.0	
AEC.....	8.6	
NIH.....	(0)	
Office of Saline Water, Department of Interior.....	.4	
Total.....	47.2	11.1

¹ Not available.

While some of the information concerning the Department of Defense is uncertain, we believe, on the basis of informal information, that the estimate is realistic. The NASA traineeship reduction is included since additional graduate research assistantships under various research projects will be requested as replacements for these traineeships. No accurate data are available for the National Institutes of Health but a reasonable estimate would be \$15-20 million. The total proposal pressure of this type will therefore be about \$75 million. Of this amount, about 80% or about \$60 million we estimate would be of such value that the work should be continued.

The provision of \$10 million in the Foundation's budget for increased proposal pressure is specifically intended for high-quality projects being discontinued by other agencies. It is difficult, therefore, to estimate the percentage of the \$10 million which might go for the support of young investigators. In general terms, about 45% of all academic scientists receiving research support from the Federal Government in 1968 received their doctoral degrees no more than six years previously. Thus in "normal" research support, about half of the funds would be used for the support of research by young investigators.

SOME PERSONS WELL KNOWN IN SCIENTIFIC RESEARCH WHOSE SUPPORT IS BEING TERMINATED BY DEPARTMENT OF DEFENSE

Investigator	Institution	DOD agency
Prof. Hans Bethe.....	Cornell University (Nobel laureate).....	ONR
Prof. L. I. Schiff.....	Stanford University.....	AFOSR
Prof. M. L. Goldberger.....	Princeton University.....	AFOSR
Prof. W. A. Fowler (NSB).....	California Institute of Technology.....	ONR
Prof. Gordon Stanley.....	California Institute of Technology (Owens Valley Radio Astronomy Laboratory).....	ONR
Prof. C. W. Hastings.....	Harvard University.....	ONR

Shifts in program emphasis by agencies other than the National Science Foundation are causing a reduction in the support of academic research in many institutions by at least \$47.2 million, and possibly by \$58.3 million, in FY 1971. These totals do not include changes in the programs of the National Institutes of Health; information on these changes is not presently available. Present plans of other agencies include the termination of research grants or contracts in more than

three-quarters of the States. Most, and perhaps all, of the remaining States will be affected since many of these projects will be of very high quality and will compete successfully for Foundation support.

A summary table is given on the next page and more detailed information is provided on the following pages.

REDUCTION OF ACADEMIC RESEARCH SUPPORT, FISCAL YEAR 1971

[In millions]

	Firm information	Uncertain information
Department of Defense:		
Air Force.....	\$7.7	\$8.3
Navy.....	2.8	0.3
Army.....	1.0	1.1
ARPA.....	0.5	1.4
Department of Defense subtotal.....	12.0	11.1
NASA:		
Sustaining university program.....	7.0	
Traineeships.....	4.2	
Other research.....	15.0	
Atomic Energy Commission.....	8.6	
National Institutes of Health.....	(1)	(1)
Office of Saline Water, Department of the Interior.....	0.4	
Total.....	47.2	11.1

¹ Not available.

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Institution	Title	Prior annual rate of support
Massachusetts Institute of Technology.....	Use of Organometallic Reagents in the Synthesis of Structurally Specific Organic Materials.	\$36,000
University of Chicago.....	Magnetic and Optical Properties of High Temperature Liquid and Solid Systems.	46,316
Georgetown University.....	Chemistry of Heteropoly Compounds and Their Relation to Catalysis Properties and the Synthesis of New Materials.	59,400
University of Georgia.....	EPR Spectrometry.....	26,600
Northwestern University.....	Vibrationally Excited Molecules.....	43,831
University of Massachusetts.....	Inorganic Coordination Compounds.....	10,000
Texas Technological University.....	New Reactive Intermediates.....	37,800
University of Texas at Arlington.....	Stable Aqueous Gold Solutions.....	8,700
Brown University.....	Molecules Containing vic Non-bonded Electron Pairs.....	49,700
Emory University.....	Compounds of Niobium.....	20,400
University of Georgia.....	Coordination Compounds of Transition Metals.....	48,800
Massachusetts Institute of Technology.....	Reactive Intermediates.....	39,000
Indiana University.....	Computer Methods in Chemistry.....	75,000
California Institute of Technology.....	Quantum Chemistry Program Exchange.....	26,000
Stanford University.....	Photochemistry and Reactivity.....	55,000
Indiana University.....	Physical and Mechanical Properties of Macromolecules.....	115,000
State University of Iowa.....	Chemical Research.....	25,000
University of Florida.....	do.....	9,000
University of Florida.....	do.....	28,000
Yale University.....	do.....	65,000
University of South Carolina.....	do.....	14,000
Indiana University.....	do.....	73,000
Yeshiva University.....	do.....	18,000
Northwestern University.....	do.....	14,000
University of Florida.....	do.....	33,000
University of Oklahoma.....	do.....	24,000
Case-Western Reserve University.....	do.....	17,000
University of Virginia.....	do.....	18,000
State University of Iowa.....	do.....	9,000
University of Notre Dame.....	do.....	24,000
University of Tennessee.....	do.....	25,000
University of Wisconsin.....	do.....	25,000
State University of New York.....	do.....	31,000
Harvard University.....	do.....	53,000
University of Maryland.....	do.....	21,000
Tufts University.....	do.....	21,000
Princeton University.....	do.....	25,000
University of Minnesota.....	do.....	35,000
Pennsylvania State University.....	do.....	18,000
Tufts University.....	do.....	12,000

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

Institution	Title	Prior annual rate of support
Johns Hopkins University	do	\$39,000
University of Southern California	do	50,000
State University of New York at Buffalo	Coemical Research	15,000
California Institute of Technology	do	35,000
University of Florida	do	10,000
University of California at Berkeley	do	30,000
Texas A. & M. University	do	14,000
Case-Western Reserve University	do	17,000
University of California (Berkeley)	Bio-Control Systems	24,000
Duke University	Partial Differential Equations	27,000
University of Miami	Interpolation Theory	19,000
Do	Automata Theory	19,000
Rensselaer Polytechnic Institute	Nonlinear Control	19,000
University of Rochester	Modelling Complex Systems	71,000
Massachusetts Institute of Technology	Global Analysis	59,000
Yale University	Celestial Mechanics	37,000
University of North Carolina	Combinatorial Mathematics and Applications	44,000
Massachusetts Institute of Technology	Algebra, Analysis and Topology (Moore Instructorships)	38,000
Yale University	Mathematics (Gibbs Instructorships)	17,000
Indiana University	Mathematical Analysis (Hlavaty Instructorships)	10,000
Rensselaer Polytechnic Institute	Discontinuous Non-linear Systems	17,000
University of Chicago	Structural Stability of Rotating Fluid Systems	17,000
University of Maryland	Electromagnetic and Critical Phenomena in Solids	66,000
University of Illinois	Theory of Solids and Condensed Matter	65,000
Wesleyan University	Mossbauer Effect in the Study of Solids	30,000
University of Utah	Plasma Effects in Solids and Low Frequency Effects in Superconductors	40,000
University of Rochester	Magnetic Interactions in Metallic Systems	30,000
University of Connecticut	Electrical and Thermal Properties of Impure, Single Crystals	25,000
University of Arizona	Physical Properties of Solids at High Pressures	49,000
The John Hopkins University	Spectra of Doubly and Triply Ionized Rare Earths	30,000
Duke University	Centimeter, Millimeter and Submillimeter Waves	137,000
California Institute of Technology	High Resolution Studies of Discrete Radio Sources	35,000
Stanford University	Plasma Physics and Plasma Phenomena of Astrophysics	50,000
University of Miami	Relativistic Plasma Physics	28,000
Dartmouth College	Hydromagnetic Wave-Particle Beam Interactions	34,000
University of Chicago	Studies of Meson-Baryon Interactions	26,000
Catholic University	Basic Research in Cosmic Neutrino Physics	80,000
University of Michigan	Radio Pulses from Cosmic Ray Showers	36,000
Syracuse University	Irreversible Processes and General	35,000
State University of New York	Axiomatic Quantum Field Theory and Scattering of Elementary Particles	26,000
University of Michigan	Theory of Weak Interactions and Electrodynamics	22,000
University of Florida	Meson Theoretical Potentials for Nuclear	39,000
University of Boston	Studies in Particle Physics	36,000
Ohio State University	Transport Phenomena in Metals at Low Temperature	29,000
University of Southern California	Electron Probe Analysis of Semiconductors	38,000
University of California	Electronic Structure of Metals	52,000
Clemson University	The Effect of Elastic Strain on Several Crystals Properties	34,000
University of Virginia	Surface Scattering and Other Surface Phenomena	40,000
University of Maryland	An Optical Interferometric Method to Eliminate the Atmospheric Degradation of Resolution	25,000
Columbia University	Magnetic Fields in Stars and Galaxies	56,000
University of California at Los Angeles	Chemical Compositions of Gaseous Nebulae	26,000
Yeshiva University	Astrophysical Research	100,000
Cornell	Pulsars	93,000
Columbia	Magnetic Fields in Star and Galaxies	30,000
California Institute of Technology	Stellar Composition and Nuclear Processes	75,000
University of California at Los Angeles	Chemical Composition of Gaseous Nebulae and Peculiar Stars	25,000
University of Maryland	Optical Methods to Eliminate Atmospheric Degradation of Resolution	17,000
University of Sydney (Australia)	Stellar Intensity Interferometer	75,000
Stanford University	Heterogeneous Nucleation in Vapor Deposition	45,000
Washington State University	Flow Mechanisms In Crystals	14,000
Case-Western Reserve University	Mechanical Properties of Refractory Alloys	25,000
University of Illinois	Defects in CsCl Ordered Alloys	32,000
	Clustered Defects in Solids	34,000
University of Southern California	Electron Probe Analysis of Semiconductors	37,000
Florida State University	Nuclear Accelerator Laboratory	324,000
Massachusetts Institute of Technology	National Magnet Laboratory (reduction in level)	450,000
13 other projects		370,000

AIR FORCE (OTHER)

Institution	Title	Prior annual rate of support
Massachusetts Institute of Technology	Investigation of Atomic and Molecular Processes	\$54,000
Temple University	General Relativity	25,000
Pittsburgh	do	30,000
University of Texas	do	60,000
Primate Center at Holloman AFB		1,000,000
In addition, to keep the 140 ft "Haystack" antenna facility in operation for astronomy will require.		1,600,000

NAVY

University of California	Magnetic Fields as Related to Ionospheric and Magnetospheric Disturbances.	\$80,000
California Institute of Technology	Nuclear and Electromagnetic Interactions with matter	75,000
Harvard University	Nuclear and Electromagnetic Interactions as Related to Prediction of Radiation Effects and Shielding.	43,000
Princeton University	Gravitation, Solar Radiometry, Thermal Radiation, and Communications.	60,000
Cleveland State University	Electron Dynamics and Cyroscopic Motion	30,000
University of Chicago	Gravitational Radiation and Dynamics of Fluid Systems	40,000
Do	Ferromagnetic and Antiferromagnetic Materials at Low Temperature.	20,000
University of California	Magnetic Resonance in Metals and Alloys	21,000
Duke University	Thermal and Magnetic Properties of Electronic Insulators at Low Temperatures.	22,000
University of Maryland	Statistical Aspects of Complex Systems	16,300
Harvard University	Ocean Wave Propagation and Meteorological Phenomena such as the Dynamics of Hurricanes.	23,000
Stanford University	Biomechanics Studies of Detached Retina, Vestibular Apparatus (Inner Ear) and Other Body Components.	20,000
Michigan State University	Raman Effects from Molecules and Crystals	50,000
Massachusetts Institute of Technology	Intermolecular Forces	24,300
The Ohio State University	Infrared Spectroscopy and Symposium	10,900
University of Wisconsin	Properties of Atoms and Their Effect as Impurities on the Electrical-Device and Optical-Detection Potential of Solids.	25,000
University of California	Theory of Electronic Behavior in Solids Relating to Electrical, Optical and Magnetic Properties.	47,000
University of Chicago	Theory of Properties and Structure of Crystals, Glasses, Liquids, and Organic Materials.	29,000
Stanford University	Analysis of Macromolecules Using Scattering of Laser Radiation.	15,000
Cornell University	Astrophysical Sources of Radio Noise	25,000
	Effects of High Altitude Nuclear Detonations and Natural Occurring Radiations on Naval Communication Systems.	50,000
University of Michigan	Nuclear and Electromagnetic Interaction Studies using Group Theory Methods.	47,500
University of Colorado	Physics of the Solar Corona as Related to the Navy Environment.	11,500
University of Minnesota	Proper motions for Increasing Accuracy of Stellar Positions.	12,000
University of Chicago	Stellar Measurements for Increasing Positional Accuracy of Stars.	20,000
Case-Western Reserve	Search of the Southern Milky Way for Objects with Unusual Properties or Energetic Radiation that Create Conditions under which the Navy Operates.	13,600
Yale University	Neurological Mechanisms Underlying Psychological Changes.	23,000
Massachusetts Institute of Technology	Control of Dental Caries by Dietary Means	20,000
Columbia University	Production and use of Antibodies Specific for Nucleic Acids in Control of Life Processes.	21,000
Harvard University	Mechanism and Utility of Bioluminescence	29,000
Institute of Medical Sciences	Biochemical Aspects of the Atrophy of Tissue as a Result of Lack of Use, with Special Emphasis on Visual Structures.	18,800
University of Dayton	Biochemistry and Biophysics of Muscle Contractions as an Irreversible Thermodynamic Mechanochemical Conversion Process.	18,800
Lehigh University	Enzyme Production by Marine Bacteria	23,000
Princeton University	Investigation of Skilled Muscular Response Learning of Naval Tasks.	24,000
University of Hawaii	How Navy Men Develop their Attitudes toward Re-enlistment.	42,600

NAVY—Continued

Institution	Title	Prior annual rate of support
Institute of Pennsylvania Hospital	Ways for Captured Personnel to Resist Brainwashing	\$39,000
Princeton University	Identification of Factors which Make Navy Organization Resist Change.	24,000
University of Southern California	Chemical and Pharmacological Characteristics of Toxin Associated with Red Tide.	24,600
City of Hope Medical Center	Biochemical Basis for Behavior of Marine Organisms	36,300
California Institute of Technology	Radio Star Interferometry	425,000
University of California at Berkeley	Millimeter Wave Astronomy	42,000
Louisiana State University	Atomic Scattering Theory	16,000
Duke University	The Relation Between Magnetic and Mechanical Properties of Electrons in Atoms by High-Resolution Spectroscopy.	18,000
Massachusetts Institute of Technology	Peristaltic Pumps and Associated Fluid Flows in Abnormal Environments.	5,000
Woods Hole Oceanographic Institution	Ocean-bottom geothermal measurements as they relate to deep-ocean circulation, sedimentary processes, and the tectonic/volcanic activity on the sea floor.	85,000
New York University	Atomic Scattering in Quantum Magnetometers	22,000
University of California	Magnetic and Superconducting Properties of Materials.	30,000
	Effects of Pressure and Temperature on Fluorescence of Materials.	29,000
University of Rhode Island	Distributions of trace elements in sea water	65,000
	The petrology of submarine volcanics and the factors which control their distribution, origin, and activity.	105,000
University of Maryland	Chemical equilibria in sea water and their effect on Acoustic Properties.	35,000
Johns Hopkins University	Bioacoustic Behavior of Pinnipeds (Seal and Sea Lions)	37,000
University of California	Environmental Stimuli Influencing Planktonic Behavior	12,000
American Museum of National History	Functional Significance of Underwater Sound Production in Coastal Fishes.	14,000
Harvard University	Gas Reaction Kinetics of Importance to Chemical Propulsion.	23,000
Ohio State University	Reef Formation by Calcareous Algae	14,000
University of Rochester	Statistical Mechanics of Polymers and Large Chain Molecules.	30,000
Stanford University	Reliability of Multistage Selection Technique in Automata and Machines.	19,000
University of Rhode Island	Acoustics of Molten Metals and Impurity Detection	20,000
University of Maryland	Low Noise Detectors	25,000
University of Hawaii	Geochemistry of the Carbonate Cycle in the Marine Environment.	47,000
University of California	Investigation of Pilot's Ability to Control Navy Aircraft.	18,000
Stanford University	Astrophysical Sources of Radio Noise and Interference	15,000
Harvard University	Study of Nuclear Properties in the Superconducting State using Mass Spectrometer, using NMR.	111,000
Murray State University	Properties of Nuclear Induced Highly Ionized Particles Including Atomic Spectra Charge States and Stopping Power.	30,000
Wesleyan University	Establishing Reference System of Galaxies for Determining Fundamental Star Positions.	5,000
State University of New York	Description of Stellar Plasmas for Application to High Temperature Plasma Systems.	16,000
University of California School of Medicine	Computer Analyses of Nervous System Activities as Related to Fatigue.	26,000
University of California at Los Angeles	Nerve Cell Function Basic to Regenerating Nerve in Wounded Naval Personnel.	8,000
University of Massachusetts	Basic Theory of Binding Forces and the Properties of Simple Solids and Liquids.	13,000
University of Chicago	Statistical Mechanics of Complex Systems	15,000
University of Maryland	Properties of Liquids and Liquid Crystals	17,000
University of Minnesota	Primary Cosmic Radiation: Its interactions with the ionosphere, its effects on communications and on space vehicles and instruments.	138,000
Scripps Institution of Oceanography	The detection and geochemistry of trace elements in the ocean.	27,000
	The alternation and solution of natural materials in the marine environment and the effects of these chemical processes on deep-sea sediments.	46,000
Arizona State University	Classical and Quantum Electron Theory	15,000
Yale University	Atomic Scattering of Electrons	20,000
Polytechnic Institute of Brooklyn	Quantum Theory of Coherent Laser Light and Non-linear Optics.	20,000
University of Maryland	Anomalous Large Scattering of Light by Fluids Near the Critical Point.	35,000
Texas Christian University	Spectra In Crystals	10,000
Georgia Institute of Technology	Properties of Dielectrics Subjected to Electromagnetic Radiation with Wavelength in the Submillimeter (Far Infrared) Range.	13,000

NAVY—Continued

Institution	Title	Prior annual rate of support
Arizona State University	Heat and Charge Flow Through Oxide Insulations	\$23,000
University of Washington	Chemical studies of the oceanic environment	141,000
Texas A. & M. University	Deep Ocean Benthos	95,000
Bernice P. Bishop Museum	Dispersal of Oceanic Air-Borne Insects	39,000
Georgetown University	Pharmacological Responses of Sharks	5,000
California Institute of Technology	Comparative Physiological Studies	25,000
University of California	Hydrologic Optics	16,000
Florida State University	Spectroreflectivity Determination of Sonic Scattering Layer Occurrence	36,000
Oakland University	Mathematical Description of Visual and Auditory Perception in Navy Display Technology	13,000
University of California	Systems or Dimensional Analysis of the Research and Development Process	3,000
Do	Information Systems	3,000
University of Michigan	Radio Astronomy Observations and Instrumentation	20,000
University of Miami	Role of Wind-Borne Continental Dust in Ocean Sedimentation Process	43,000
Do	Determination of the equation of state, viscosity and compressibility of sea water	68,000
University of Florida	Environmental Stimuli: Utilized in Navigation	35,000
Research Foundation of the State University of New York	Coral Reef Growth and Dynamics	39,000

ARMY RESEARCH OFFICE (DURHAM)

Wayne State University	Luminescence of Organic Molecules	\$12,000
Louisiana State University at New Orleans	Organic Photochemistry	18,000
University of Minnesota	Chemical Research	15,000
Do	Vibrational Spectroscopy	19,100
State University of New York at Buffalo	Chemical Research	18,000
Stanford University	Valence Bond Isomers of (4N-2) Electron Systems	25,600
Purdue University	Chemical Research	16,500
University of California at Los Angeles	do	15,000
Cornell University	do	18,000
University of California at San Diego	Correlation of Bond Lengths with Orbital Hybridization	20,000
University of California at Irvine	Theoretical Study of Bimolecular Reactions	19,100
University of Utah	Thermochemistry of Organic Molecules	17,000
Research Triangle Institute	Chemical Research	15,000
University of Maryland	do	14,000
University of Pennsylvania	do	18,800
University of Virginia	do	15,000
Louisiana State University at New Orleans	do	18,000
Duke University	do	
Ohio State University	do	19,000
Iowa State University	do	17,300
Massachusetts Institute of Technology	do	23,000
University of Illinois	do	14,300
University of Iowa	do	16,500
27 other projects		670,000

ARPA

Princeton University	The Social Bases of Governmental Performance	\$150,000
Yale University	Positronium	90,000
Cornell University	Arecibo Observatory (reduction of support)	300,000

NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION SUSTAINING UNIVERSITY PROGRAM¹

University of Arizona	Multidisciplinary Research in Space Science and Technology	\$67,000
Brown University	Multidisciplinary Space-Related Research	33,000
University of California	Interdisciplinary Space-Oriented Research in the Physical, Biological, and Engineering Sciences	300,000
California Institute of Technology	Research in Physics and Astronomy	200,000
Colorado State University	Biology and Engineering of Space and Planetary Life Systems	35,000
University of Denver	The Exploitation of Unused NASA Patents	100,000
	Extending the Universities' Role in the Exploitation of Aerospace Technology	100,000
Drexel University	Multidisciplinary Research in Composite Materials and Plasma Engineering	100,000
	Research and Graduate Education in the Application of Technology to Social Problem Solution	117,000
Duke University	Multidisciplinary Research in the Application of Aerospace Technology to High Speed Ground Transportation	100,000

¹ See footnote at end of table, p. 56.

NATIONAL AERONAUTICAL AND SPACE ADMINISTRATION SUSTAINING UNIVERSITY PROGRAM I—Continued

Institution	Title	Prior annual rate of support
University of Florida	Research in Space-Related Sciences	\$75,000
George Washington University	Multidisciplinary Program of Policy Studies in Science, Technology and Public Administration	400,000
Georgia Institute of Technology	Multidisciplinary Research in Space Sciences and Technology	150,000
University of Louisville	Basic Research in Physical, Engineering and Life Sciences	44,000
University of Maine	Interdisciplinary Studies in Space-Related Science and Technology	30,000
University of Maryland	Multidisciplinary Research on the Application of High Speed Computers to Space-Related Research Problems	230,000
University of Miami	Multidisciplinary Research in Space Sciences	150,000
University of Minnesota	Multidisciplinary Research in Space Science and Technology	135,000
University of Missouri	Multidisciplinary Space-Related Research	65,000
Montana State University	Research in Space Sciences and Engineering	67,000
New Mexico State University	Multidisciplinary Research in Space Sciences and Engineering	30,000
University of New Mexico	Program for Advanced Study in Public Science Policy and Administration	150,000
New York University	Space-Related Research in Areas of Fluid and Solid Mechanics	65,000
University of North Carolina	Sciences in Interaction: A Research Program in Life, Physical and Social Sciences	250,000
Oklahoma State University	Multidisciplinary Research	25,000
University of Oklahoma	Multidisciplinary Research in Space Science and Engineering	67,000
University of Pennsylvania	Research in the Conversion of Various Forms of Energy by Unconventional Techniques	83,000
Pennsylvania State University	Multidisciplinary Space-Related Research	200,000
University of Pittsburgh	Multidisciplinary Research on the Management of Systems	130,000
	Studies in the Management and Administration of R. & D. Programs	50,000
Purdue University	Multidisciplinary Research in Space Science and Engineering	133,000
University of Southern California	Multidisciplinary Research	200,000
	Multidisciplinary Research in the Management of Large Scale Public Programs	67,000
Southern Methodist University	Multidisciplinary Research	100,000
Syracuse University	Multidisciplinary Studies in Organization and Public Policy	200,000
University of Vermont	Research with Particular Emphasis on Materials Sciences	100,000
Virginia Polytechnic Institute	Multidisciplinary Research	45,000
Washington University	Multidisciplinary Research in Space Sciences	130,000
	Application of Satellite Communications to Educational Development	100,000
University of West Virginia	Space-Related Scientific and Engineering Basic Research	100,000
Alabama A. & M. University	Development of a Computer Code	22,716
Bishop College	Synthesis of 1,2-Dimethylecyclobutadiene	12,170
	Radiolytic Grafting of Monomers to Polymeric Films	8,989
Bowie State University	Cosmic Ray Physics	24,684
Delaware State University	Specific Heat Platinin	9,061
Federal City College	Detectors for Extremely Relativistic Particles	29,434
	Phenomena Related to Spacecraft Electrochemical Devices	25,000
Howard University	Low Energy Activation Analysis	6,000
Morgan State University	Programed Course in Astronomy	16,165
	Photochromism	6,407
Oakwood College	Synthesis of Ninhydrin Analogs	24,829
Prairie View A. & M. University	Safety Analysis of Structures	15,000
	Isolating Antimicrobial Agent from Acoras	14,552
	Radiation on the Plasma Deoxyribonuclease	5,700
	Rapid Method of Determining Chloride in Rain Water; Solubility of Nickel Phosphate	5,700
	Analysis of Solid or Liquid Solutions by X-Ray Fluorescence	10,066
Talladega University	Insulators and Semiconductors Aleyamma	18,658
Texas Southern University	Interaction of Solar Radiation and Matter	6,000
	Determination of Molybdenum in Titanium Alloys	10,000
Tuskegee Institute	Develop Software Amtran 1620 Computer	24,501
	Growing of Insulating Magnetic Crystals	23,750

¹ Current rate shown, projects to be phased out; reduction in fiscal year 1971 to be \$7,000,000.

ATOMIC ENERGY COMMISSION

Institution	Title	Prior annual rate of support
University of Arizona	To Measure Lamb Shift in Hydrogen-like Atoms	\$30,000
Oregon State University	Low Energy Nuclear Research	38,000
University of South Carolina	Antineutrino Absorption Cross Section Measurement	25,000
University of Wyoming	Neutron Emission from Compound Nuclei	41,000
University of Arizona	An Investigation of Steric and Synergic Effects in Metal Chelates.	12,000
City University of New York	Development and Testing of Organic Reagents	16,000
University of Illinois	Ion Exchange Resins	17,000
Johns Hopkins University	Isotope Effects and Chemical Kinetics	29,000
Massachusetts Institute of Technology	Study of Catalytic Surfaces and the Mechanism of Catalytic Reactions.	21,000
Michigan State University	Thermodynamic, Spectral, and Structural Studies of Complex Ions.	42,000
University of Miami	Effects of Polyfunctional Anions on Electron-Transfer Between Metal Ions in Solution.	18,000
Northwestern University	Neutron Activation Analysis Studies of Iron Meteorites.	24,000
Texas A. & M. University	Use of C-14 and Tritium in the Study of Catalyzed Reactions of Hydrocarbons and Alcohols.	36,000
Wayne State University	Chemistry of the Metalloids of Group VA and VIA	12,000
Carnegie-Mellon University	Controlled Polymerization of Adsorbed Monolayers	18,000
Cornell University	Application of the Mossbauer Effect to the Study of Metallic Solid Solutions.	30,000
Michigan State University	Radiation Damage Studies Using the Cornell 3.0 MeV Dynamitron Accelerator.	21,000
University of Minnesota	Study of Interactions between f-Shell Transition Ions in Non-Metallic Crystals.	30,000
Purdue University	Effect of Short-Range Order on Mechanical Properties of Alloys.	20,000
Vanderbilt University	Mossbauer Studies of the Properties of Solids	30,000
Yale University	Deformation Studies of Superlattice Structures	6,000
Other projects, approximately	Study of Ideal Magnetic Crystals	70,000
		3,000,000

OFFICE OF SALINE WATER, DEPARTMENT OF THE INTERIOR

University of Maryland	Chemical Research	\$30,000
University of Rochester	do	30,000
University of Missouri at Kansas City	do	30,000
State University of New York at Buffalo	do	30,000
Boston College	do	30,000
Carnegie-Mellon University	do	30,000
University of Iowa	do	30,000
Rensselaer Polytechnic Institute	do	30,000
University of Pittsburgh	do	30,000
Carnegie-Mellon University	do	30,000
Baylor University	do	30,000
Purdue University	do	30,000
Cornell University	do	30,000
Syracuse University	do	30,000

UNCERTAIN INFORMATION

<i>Air Force</i>		
Astronomy and astrophysics		\$5,000,000
Atmospheric sciences		3,000,000
Engineering		300,000
<i>Navy</i>		
Oceanographic ship support		300,000
<i>Army</i>		
Atmospheric sciences		900,000
Biology		200,000
<i>ARPA</i>		
Social sciences		400,000
Seismology		1,000,000

Dr. McELROY. The \$10 million was originally put in the budget to support these projects that would be dropped by DOD. However, in looking into it further, it is clear that we are going to have increased proposal pressure which as of about a month ago was up considerably above our earlier estimates.

I don't have a current figure on this but we are going to have increased proposals over and above DOD dropouts and that increase would be coming out of the \$10 million also. But let me give you some of the actual detail on that for the record.

Senator KENNEDY. No meeting of NSF is complete without Senator Pell talking about the subject which he has devoted so much of his energy and effort to, the Sea Grant Programs. We are delighted that he can be here. I think you gentlemen know what the area of his inquiry will be. Senator Pell?

Senator PELL. I thank the chairman very much for inviting me to sit in this subcommittee. I am most appreciative. I am delighted to see here the new director who I believe is the first marine biologist, ocean-oriented Director of the National Science Foundation in the history of the Foundation itself.

Is that correct?

Dr. McELROY. That is right.

Senator PELL. I congratulate you on one thing, one particular paragraph in your testimony where you mentioned that one of your main functions is to use portions of your funds for short-range utility, often of an ad hoc character, to improve the problems of society.

Senator PELL. This is a change of philosophy of National Science Foundation and a change upon which I congratulate you because originally when we were looking for a home for sea-grant college program the National Science Foundation made its appearance kicking and screaming and now there is a good relationship.

You do an excellent job and I am glad you address yourself to practical problems as well as the long-range problems. In this connection I was wondering if you have had any further thoughts as to possibility of separate line items in the budget for sea-grant program?

Dr. McELROY. Senator Pell, as you know it has been a tradition in the Foundation—and I support that position to try to stay away from a line-item budget.

We like to keep that degree of freedom which enables us to move out into the areas of science that at the moment have the greatest possibility. Now with regard to the sea-grants program, I do not think there is any question but that it is going to stay with us for a long time.

I would not particularly worry about a line item in that regard. But as a general principle I tend to resist the line items in the budget.

Senator PELL. I understand, but do you have any line-item request in your budget now?

Dr. McELROY. No, we do not.

Senator PELL. In other words as far as you know there is just one full budget request for NSF which is not broken down by the Bureau of the Budget in any way?

Dr. McELROY. In going over the programs with the Bureau of the Budget they see a breakdown on what we propose. The congressional committees do also.

Senator PELL. But in the line-item category there is no other separate line item?

Dr. McELROY. I don't think so but I had better ask Mr. Sisco if that is a correct statement.

Mr. SISCO. There are no specific line items. There is a provision in the appropriations bill that puts a requirement for spending a specific amount on secondary school institutes but other than that there is no specific line item in the budget.

Senator PELL. I, too, think you have given a wonderful home to sea-grant college programs but if an ocean agency is set up, be it maxi or mini, it probably would go in that direction, as you know.

I see where you have been given the lead function in the International Decade of Ocean Exploration. If the mini or maxi is set up, would you still be lead agency or would the new one be the lead agency?

Dr. McELROY. At the present time we are all shored up to be the lead agency, at the direction of the Administration. As I have indicated before, Senator Pell, I have great misgivings with regard to moving the sea-grants program away from the support of basic science in all of oceanography. At the present time, as you know, we are supporting more than 30 ocean-research vessels at various institutions in this country.

We have close contact with those people. We know how to work with them. And we think we have a good organization for carrying out this program. We have contacts with an Academy group who are helping us plan this program.

So we would hate to lose the sea-grant program, not for financial reasons, but for academic and scientific reasons. When we consider putting all oceanography under one group, I think we should look at all of the disciplines and all of the programs that have an impact on oceanography, because I feel that chemistry, biology, and physics have a lot to contribute.

So it may well be if one sets up a National Oceanographic type organization it might be incorporated into NSF.

Senator PELL. That is a very interesting thought indeed. Maybe you would become the Noah, but like Jonah and the whale you would be swallowed up.

But I congratulate you, though, on the work you are doing in connection with the oceans and the support you give is tremendous. The only problem, as you know there are about 23 or 25 ocean agencies in the Federal Government concerned with the oceans and I agree it should only be your agencies that would have that function.

In conclusion I thank the chairman for letting me be here. Several years ago I remember being rather critical of National Science Foundation for their arm's length antiseptic treatment of the program but in the recent years or two and under your aegis it has gone very well indeed. As sponsor of that bill I am pleased with the way it is going and the relationship you have to it.

Senator KENNEDY. Thank you very much, Senator Pell.

I think Senator Pell indicated the whole question of relevancy is something that all of us should be very much aware of, particularly today.

A hot political item of the day is the question of environment and what we are going to do about problems of pollution and all the rest.

If we did not have the kind of work being done by NSF in that area a long time ago before the environmental issue was popular, obviously we would not be nearly as far along as we are now.

I am sure there are many things which NSF is working on which 5 years from now or 10 years from now will be as important if not more important than many of the things that we are considering today. I think as you pointed out in your testimony that, when the budget cuts come, they affect first these longer range projects which in many instance are not only as important but perhaps more important in terms of our total existence than currently pressing concerns.

So I think those comments were extremely useful.

Dr. McELROY. I think it is very important to the National Science Foundation that people realize that, as Dr. Handler said earlier, the solution to many of these pollution- and environmental-type problems is more a sociopolitical decision than a scientific and academic decision. Now it is certainly true that there are a lot of areas where good basic research and applied research has to be done before we can come up with an adequate solution. But it certainly is not the intent of the Foundation, as indicated before, to move wholly in the direction in which other agencies should be moving. We can develop the scientific manpower and the basic science knowledge for the solution but we cannot supply all the leadership, for it is a political social decision that has to be made.

It is important that the Foundation keeps itself as a primary agency for support of basic science in these problems of pollution. Many of them we are getting at through sea-grants programs. Here we are coming up with a lot of good information to be put to use. I emphasize that the Foundation must be responsive to basic science in this country. These additional new things are only effective add-ons.

Senator PELL. I was at the University of Hawaii 3 days ago and they are doing some work in this regard with your support.

Senator KENNEDY. Dr. Handler, would you like to make any concluding observation?

Dr. HANDLER. What I had in mind, Dr. McElroy has said already.

My concern, Senator, is this. We are responsible not only to our contemporaries but for the needs of our grandchildren. That means we must be careful that we do not allow the seemingly urgent problems of the moment to drive out consideration of the important long-range ones. To be sure, just as Senator Pell indicated, we must be responsive to the needs of the moment—and the quality of environment is of great moment to all of us—but we also have to get on with the science our successors are going to use, 25 and 50 years from now, to solve their problems.

The Science Foundation is the one agency in Government which has a clear mandate to sustain fundamental research in all areas of science, while it does what it can about the programs of the moment. Moreover, through its training programs it should be preparing the young scientists who will undertake both fundamental research and its application. All such activities are expensive—but they are the best investment the Nation can make.

Senator KENNEDY. Thank you very much. Let me just commend you gentlemen again for your responsiveness and frankness in terms of our inquiry, particularly in these budgetary items. We know, as I mentioned at the outset, that you are operating under some restraints but you have been responsive in giving us the information and responding to these questions.

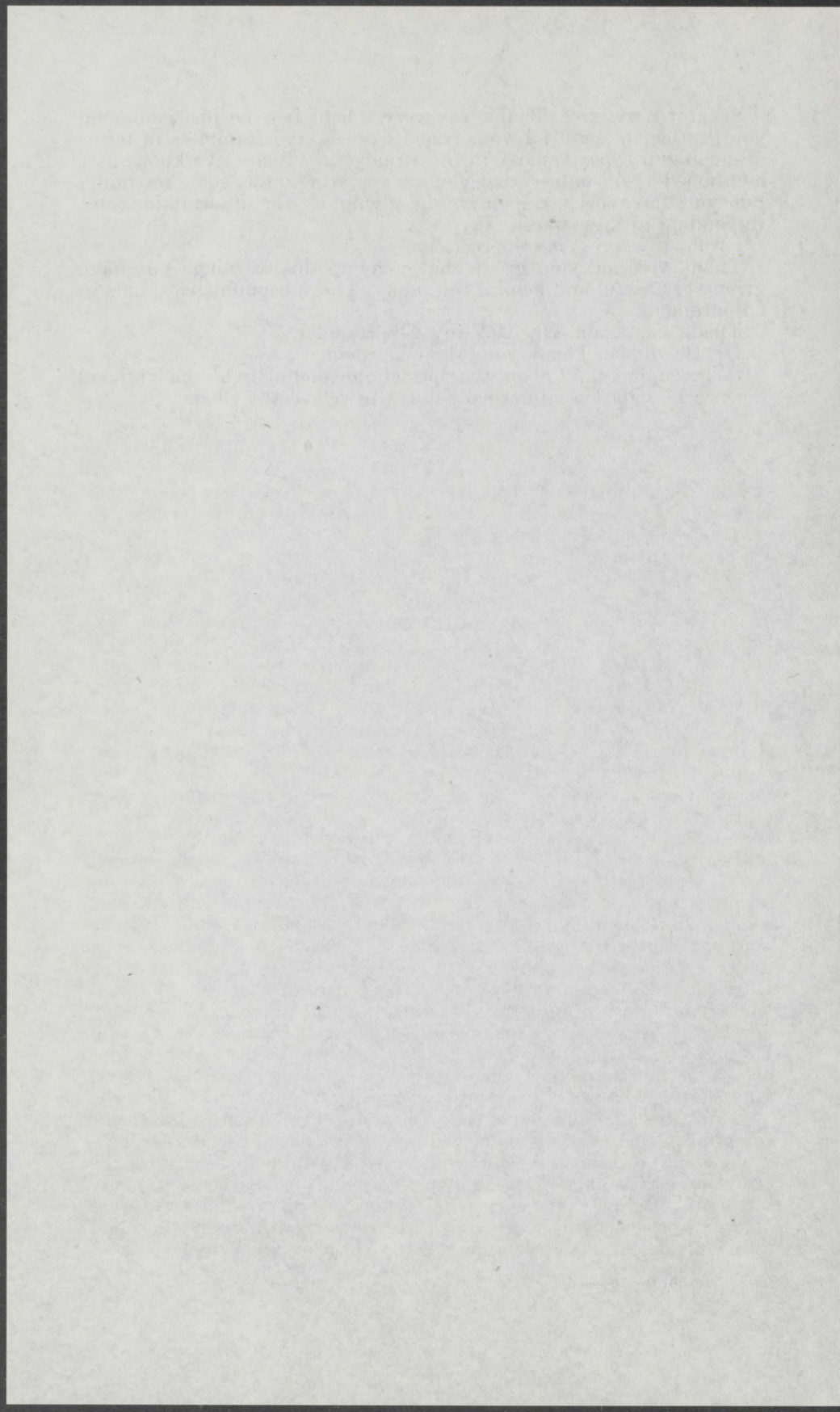
I want to express my appreciation.

Thank you and your group that came up this morning. You have given very useful and helpful testimony. The subcommittee stands in adjournment.

Thank you again, Dr. McElroy, Dr. Handler.

Dr. HANDLER. Thank you, Mr. Chairman.

(Whereupon, at 12 noon, the Special Subcommittee on the National Science Foundation adjourned subject to call of the Chair.)



NATIONAL SCIENCE FOUNDATION AUTHORIZATION, 1971

THURSDAY, APRIL 23, 1970

U.S. SENATE,
SPECIAL SUBCOMMITTEE ON THE
NATIONAL SCIENCE FOUNDATION OF THE
COMMITTEE ON LABOR AND PUBLIC WELFARE,
Washington, D.C.

The subcommittee met at 2:20 p.m., pursuant to call, in room 1313, New Senate Office Building, Senator Edward M. Kennedy (chairman of the special subcommittee) presiding.

Present: Senator Kennedy.

Staff member present: Roy H. Millinser, minority staff member.

Senator KENNEDY. The subcommittee will come to order.

Today the Special Subcommittee on the National Science Foundation holds its second day of hearings on the Foundation's 1971 authorization. We have before us S. 3412, introduced by Senator Prouty, and S. 3700, which I introduced and which increases the Administration authorization by \$50 million.

Last week we heard from Dr. Handler and Dr. McElroy of the Foundation. They, of course, supported the Administration's budget request. But they also gave us a frank account of the difficulties now facing scientific research. We are happy today to welcome another representative of the Administration, Dr. Hubert Heffner. Dr. Heffner is the Deputy to President Nixon's Scientific Advisor, Dr. Lee A. DuBridg, who was unable to attend because of a previous engagement.

We are greatly honored to have as additional witnesses all four former scientific advisors to the President: Dr. James Killian, who was the first scientific advisor to President Eisenhower, is now chairman of the board of MIT. Dr. George Kistiakowsky, who also served under President Eisenhower, is now a professor of chemistry at Harvard and a leading proponent of arms control. Dr. Jerome Wiesner, who served under President Kennedy, is now the provost of MIT, and, like Dr. Kistiakowsky, a leading expert on arms control. Dr. Donald Hornig, President Johnson's scientific advisor, is currently a vice president at Eastman Kodak and is the president-elect of Brown University.

I think it is an indication of the crisis mood of the American scientific community that such distinguished and busy scientific leaders believe it necessary to take time out from their schedules to testify on the NSF authorization. As Dr. Handler told us at our last hearing, many scientists are now "very seriously discouraged as to what the future holds." Young scientists, in particular, are worried that they may not receive sufficient Federal support to do the work they have been so ably trained to do.

I intend to ask our distinguished witnesses whether the fears of the American scientific community are justified and, if so, what the impact of cutbacks in scientific research will be on our Nation. Will we be able to meet the health needs of our people, clean up the environment, and find new sources of food and power if the scope of the scientific enterprise is reduced? Will we be able to make up for reductions today by greater expenditures a few years from now, or is it impossible to turn scientific research on and off like a faucet? It is my hope that the Congress and the public will pay close attention to the answers you give to these crucial questions.

For my part, I believe that the Administration is making a woeful error in cutting back so substantially on basic scientific research. I recognize the need for budgetary belt-tightening in a period of inflation. But even in a period of inflation, a responsible government must choose its priorities wisely; it cannot blindly slash every Federal program. And it is my belief that no government with a proper set of priorities can, at this moment in history, seriously consider reducing its commitment to scientific research. We are just on the verge of reordering our national priorities, of freeing more scientists to work on civilian rather than military problems. I do not understand how this can be the time to cut back on support for science and scientists.

Dr. Heffner, would you be kind enough to come forward first, and then we will ask our other witnesses to come together as a panel? We appreciate very much your being here.

STATEMENT OF DR. HUBERT HEFFNER, DEPUTY DIRECTOR OF THE OFFICE OF SCIENCE AND TECHNOLOGY

Dr. HEFFNER. Thank you, Senator Kennedy.

I bring the regrets of Dr. DuBridge, who had a longstanding speaking engagement and otherwise, of course, would have been here.

May I make a short statement and then I will invite any questions which you have?

Senator KENNEDY. Yes, I wish you would.

Dr. HEFFNER. The National Science Foundation is of fundamental importance to the Nation's strength in science and technology. From its beginning in 1950, this agency has been charged with and has fulfilled the responsibility of "initiating and supporting basic scientific research and of appraising the impact of research upon the industrial development and the general welfare." Moreover, the National Science Foundation has taken on and carried out with distinction the responsibility to strengthen science education from the grade school to the highest level which our Nation's universities offer.

At this point in history, the National Science Foundation is faced with a greater task than ever before. Not only is the Foundation taking on new responsibilities for research of a problem-oriented nature, but at the same time the cutbacks in funding of research by the mission-oriented agencies, such as the Department of Defense and the National Aeronautics and Space Administration, have forced large numbers of well-qualified scientists to turn to NSF for support of their work.

The budget of NSF as proposed by the President to the Congress can provide for increased emphasis on this problem-oriented research

and at the same time can accommodate a number of these new applicants where their research is of high quality. As an illustration of the President's interest in obtaining a strong research capability, even in this year of extreme budget stringency, the President's funding request for NSF provides for an increase for scientific research support of \$36.6 million over the 1970 level. This figure includes an increase of \$15 million for individual research project support.

Several changes have been made over past NSF budgets. Let me mention a few. One is the increased emphasis on programs designed to provide the fundamental knowledge and trained manpower needed to meet the pressing challenges for our society posed, for example, by the deterioration in the quality of our environment. The budget also reflects an attempt to cope with the shift away from support of fundamental research by the mission agencies and the corresponding increased pressure on NSF to support such research. Ten million dollars of the budgeted increase for research-project support is to permit NSF support of the best projects being dropped by the mission agencies. Moreover, some of the research which is being dropped by the mission agencies can be picked up by NSF under its new problem-related programs.

The 1971 NSF budget also includes a reduction in the number of graduate traineeships. Several considerations entered into this decision. First, the Ph. D. pool in the engineering, physical, and mathematical sciences has been growing at 9.4 percent per year for the past several years—a rate almost six times that of the increase in general population of the country. This fact, coupled with the reduction in the traditional Ph. D. job opportunities both now and in the relatively near future, has led to a decision to reduce the number of traineeships next year. However, this is a subject which needs careful continued evaluation in view of the long timescale between policy decision and its resulting effect on Ph. D. output. Accordingly, the policy regarding fellowships and traineeships is currently under critical review and study by the Office of Science and Technology and the Bureau of the Budget in conjunction with the various agencies. The outcome of this further study will be a primary consideration in the development of the fiscal year 1972 budget.

I hope this committee is as impressed as we are by the leadership displayed by Dr. William McElroy in his first year as Director of the National Science Foundation. The new demands on the Foundation are being met with vigor, enthusiasm, and, above all, new ideas. We believe that he and his new team of assistant directors merit our most generous support. I say particularly because, if one looks at the history of National Science Foundation budgets, the fact is that the appropriations by the Congress in recent years have fallen far short of the budget requests of the President or, in 1970, the first year of authorization, the congressional authorization. The President's total request for NSF for fiscal year 1970, the current fiscal year, was \$500 million, of which Congress provided only \$442 million. For fiscal year 1971, the President has requested \$513 million, \$500 million of which is the subject of authorization by this committee. The President wishes to express clearly his desire for a fully funded budget for 1971 for the scientific research and educational programs of the Foundation.

Senator KENNEDY. Thank you very much, Doctor Heffner. I was wondering if you could give us an estimate of the cutbacks that will be made by the various mission-oriented agencies. You must have made some estimates of those cutbacks.

We had Dr. McElroy give us an estimate. I was just wondering what your information is on that question.

Dr. HEFFNER. Of course, the question is not possible of answer with complete certainty at this time in terms of the 1971 situation, because, as you are perfectly aware, the budgets have not been appropriated for the agencies. But so far as the present situation—

Senator KENNEDY. Let us take it for budgetary requests.

Dr. HEFFNER. All right, budgetary requests. I think you will find even there we are beginning to get new information. In terms of the budgetary requests, there is a reduction—I now speak of the academic science component; that is, the research done in universities and colleges—there is a reduction in the Department of Defense of only about \$1 million anticipated in the preparation of the budget. We now believe that is probably going to be a little more, speaking of 1970 over 1971. In terms of the reduction between 1969 and 1970, it is nearly \$20 million.

As far as NASA goes, the difference between this current fiscal year and the Administration budget is approximately \$26 million.

Now the numbers, particularly for the Department of Defense, are not entirely hard. The reason lies in the fact that the estimates which are made for the support by the services for basic research come from the services themselves, and those are under continuing review. I think that we are beginning to find that, whether it is section 203 or simply budget stringencies, that the services are beginning now to estimate somewhat less funds will be devoted to the so-called academic research than they anticipated back at the time the budget was made up.

Incidentally, I might add that we are keeping close tabs on this situation and that this subject will be a topic of concern in the June budget review of the Administration.

Senator KENNEDY. Of course, you would want to include the cuts in HEW.

Dr. HEFFNER. That is correct.

Senator KENNEDY. What are those estimates?

Dr. HEFFNER. The estimates at the time the budget was made up were actually an increase in the amount of research by the National Institutes of Health and HEW in general.

Senator KENNEDY. In terms of research?

Dr. HEFFNER. In terms of research.

Senator KENNEDY. In basic research?

Dr. HEFFNER. I am speaking now of the research going to the academic institutions. My belief is that basic research in general is up in 1971 over 1970. On the other hand, 1970 showed a reduction over 1969.

Senator KENNEDY. Can you give us a sort of ball-park figure of the cuts that have been made by these mission-oriented agencies? I believe Dr. McElroy estimated a minimum of \$50 million. Congressman Daddario has estimated at least \$60 million in 1970. Can you give us some kind of figure which we on the committee and in the Senate—

Dr. HEFFNER. Our best estimate is that in the area of research covered by the National Science Foundation we anticipate a reduction in the other mission agencies of about \$31 million. The difference in the figures of the National Science Foundation or Representative Daddario occurs because of their assessing what projects would be dropped, rather than what the budget difference was in those agencies.

Senator KENNEDY. You estimate approximately \$30 million. Now as I understand it the \$30 million cutback or the \$50 million cutback in research by other agencies is only offset by \$10 million in the NSF budget. Is that correct?

Dr. HEFFNER. That is correct.

Senator KENNEDY. Researchers dropped by other agencies also will have to compete with new programs for that \$10 million. You will have the \$30 million worth of research dropouts which you estimate or the \$50 million which NSF estimates, all trying to divide that \$10 million pie with new applications by young scientists and others. At least, that is the impression that I have. If I am not correct, maybe you can correct me.

Dr. HEFFNER. I think that is true, sir. There are, however, new programs of the problem-oriented research which may serve to assist some investigators who were cut off from the mission agencies, because there is some desire on the part of university research people to transfer their interest to these newer areas of research in problems of environment in cities, and so forth.

Senator KENNEDY. I am sure in your evaluation of these cuts you have studied what specific research will actually have to be cut back in these various mission-oriented agencies. I would like, if we could, at least to have for this record what information was assembled by Dr. DuBridg and yourself and what evaluation you place on the various programs which are being dropped. I think this would at least permit this committee and the Senate to have some idea of the type of programs that are being cut back; and then at least we might be able to try, through additional study, to make our own judgment as to the importance of the projects being dropped.

Dr. HEFFNER. I think our concern in reviewing the cutbacks focuses on three or four main areas. The Defense Department is cutting back severely on research on radioastronomy, nuclear physics, and mathematics. Now, I include mathematics in that category because, although the amount of support for mathematics is relatively small, it has been severely hit by the requirements for immediate relevance in the Defense Department. And the Defense Department has borne a heavy share. And the previous ones I mentioned are perhaps the most severely hit in terms of the total amount of money.

Senator KENNEDY. Could you respond on the question of the fellowships and traineeships somewhat more? You left it somewhat up in the air. I believe there is going to be a continuing review of the program. Perhaps you have had an opportunity to see the testimony of Dr. McElroy in which he indicates that there will be a review of this program.

One of the issues—and let me be the devil's advocate on this question, because it comes up time and time again and will probably come up on the floor—is that fellowships provide an opportunity for the winners to go to whatever universities or colleges they might desire. The traineeships on the other hand go to the colleges themselves.

Don't you feel that, by putting the stress on the fellowships, we will have more students going to the science meccas of the country and thereby ignoring some of the other schools and colleges? I am going to ask my friends from Harvard and MIT about this, but I am interested in what the administration's views on this would be.

I know from many of my colleagues on this committee that this is a matter of concern. I want to get your response on the record.

Dr. HEFFNER. I think if one relied solely on fellowships there is certainly the tendency and the danger which you suggest. The National Science Foundation made an extremely persuasive case for a continuation of the fellowship program at the same level, because it is indeed a national program in which the recipients are chosen in national competition. Their belief was, and I think I share this, that this is a nationally visible, high-quality, student support mechanism; and that, if one had only a certain amount of money available, I believe that it would accord with the estimation of the National Science Foundation that the priority be given to fellowships as opposed to traineeships.

I am sure that no one would be unaware of the difficulties which you are suggesting, however.

If I may, I would like to expand very briefly on the issue of the traineeships and the support of students. First of all, traineeships and fellowships provide something like a fifth of the student support for students in science and engineering. The remainder comes from support for research, assistantship grants, which are funded by research projects, and teaching assistantships and "others."

Senator KENNEDY. That is being cut back too, is it not?

Dr. HEFFNER. That is correct. It is not getting cut back in the National Science Foundation, but certainly is overall in the traditional fields of science. Now, if one looks at the past history of our increases in the Ph. D. pool in the country, he finds, for example, in 1968—and this is a typical year—in the physical sciences we added to that pool 7.1 percent new Ph. D. graduates; in the life sciences, 7.5 percent; in mathematics, 11.4 percent; in engineering, 14.5 percent; in the social sciences, 7.6 percent.

The point I raise here is that, at least in physical sciences and engineering, we have been adding at a rather rapid rate to that Ph. D. pool. If one looks at the anticipated programs of the National Aeronautics and Space Administration and of the Defense Department which have, through their contracts with industry, provided probably the most massive source of jobs for such students, he discovers that for the foreseeable future the rate of expansion of those programs, to say the least, is going to decrease and the level itself will probably decrease.

No, there is not that same national need for scientists and engineers doing the traditional things that they have been doing, in the future, as there has been in the past. That forms, really, the basis for the decision to reduce this year at least the traineeship programs. It is, as I say, an unstable situation in a sense, because the feedback loop is so long, the time between the decision to change the funding for Ph. D. students and the time at which those Ph. D. students would come out of the pipeline.

In such a long time interval as this it is quite easy to have ups and downs, because you have misjudged what the figure really is. That is why we are looking at it very carefully.

Senator KENNEDY. Thank you very much, Dr. Heffner. I have some other kinds of questions I would like to submit to you in writing and perhaps get a response for the record.

I want to thank you for your responsiveness. When we had Dr. McElroy here last week, I commended him for his frankness and candor. We got into a lot of these questions in some detail and I think he was marvelously responsive to our questions. You have been, too.

I want to thank you for your appearance here. Thank you very much.

Dr. HEFFNER. Thank you, Mr. Chairman.

(The questions and answers referred to follow:)

APRIL 27, 1970.

Dr. HUBERT HEFFNER,
Deputy Director, Office of Science and Technology, Executive Office Building,
Washington, D.C.

DEAR DR. HEFFNER: Thank you for your extremely valuable testimony before the Special Subcommittee on the National Science Foundation. Your presentation of the Administration's budget request was excellent.

As I made clear at the hearings, one or two aspects of your testimony requires further amplification. First, I hope you can provide the Subcommittee with a breakdown of your estimates of the cutbacks in research by mission-oriented agencies in FY 1970 and FY 1971. We would be particularly interested in an explanation of how and why your estimates differ from those of Representative Daddario's Subcommittee and the NSF itself. Second, I would be interested in a detailed analysis of basic research funded by the Department of Health, Education and Welfare, including research on photosynthesis.

Again, thank you for your excellent testimony.

Sincerely,

EDWARD M. KENNEDY.

EXECUTIVE OFFICE OF THE PRESIDENT,
OFFICE OF SCIENCE AND THE TECHNOLOGY,
Washington, D.C., May 7, 1970.

HON. EDWARD M. KENNEDY,
U.S. Senate,
Washington, D.C.

DEAR SENATOR KENNEDY: It was a pleasure to testify before your subcommittee on April 23rd. I shall attempt to answer the additional questions posed to me in your letter of April 27th.

You have asked how and why our estimates differ from those of Representative Daddario and of NSF. Basically, as I explained in my oral testimony, the difference arises because NSF has surveyed only the projects to be dropped and has not included budgetary provision within other departments for the initiation of new projects. The figure I quoted rises solely from budgetary requests for research, Departmental estimates of how much of those research funds would be spent in universities and colleges and a judgement of what fraction of those estimates represented research appropriate to NSF. The tabulation is as follows:

SUPPORT OF R. & D. IN COLLEGES AND UNIVERSITIES

[In millions of dollars]

Department or agency	Estimated expenditures		Difference
	1970	1971	
Department of Defense	220	205	15
NASA	131	105	26
AEC	100	97	3
Total			44

The FY 1970 and FY 1971 estimates of expenditures by the Department of Defense differ from those originally made by DOD and printed in Special Analysis Q (table Q3) of the Budget. These present estimates are educated guesses based on new information obtained from the Department of Defense. Of this \$44 million reduction in these three agencies, we estimate something like \$31 million is devoted to research of the type supported by the National Science Foundation.

The study done by the staff at NSF surveyed the different agencies to identify individual projects which might have to be cut during FY 1971 because of budgetary restrictions. They came up with a list of "well identified" projects which totaled \$47 million. They then added an additional \$11 or \$12 million which might have to be dropped by the Department of Defense. These figures are the basis of the "\$50 million" used by Dr. McElroy and the "\$60 million" indicated by Congressman Daddario.

While the NSF numbers are useful, they do not give a complete picture either of the funding changes in academic research in general or of the effect of the FY 1971 budget in particular. The reasons are:

1. The figures reflect only projects closed and do not take into account projects initiated (though it is true that many of the new projects are in subject areas other than those being dropped.)

2. Because of forward funding of projects, the closing of many of these represent budget stringencies in FY 1970 or even in FY 1969. That is, the decision not to renew was made earlier, but because of forward funding, the project continued for a year or more. Thus the NSF figures represent an accumulation of prior and present years' budget problems.

You ask about the details of the HEW funding for basic research. I am including a breakdown of the Administration's FY 1971 budget for NIH which shows an increase over FY 1970 of \$14 million in research grants and of \$49 million in research targeted toward specific problems, \$40 million of which is to be used in extramural contracts. The total adds up to an increase of \$63 million for research over the FY 1970 figures.

The last question concerning the decrease in support for research in photosynthesis has been investigated rather carefully by our office. After talking with many of the program officers, both at NIH and NSF, there seems to be no grounds for the statement that either agency has significantly decreased its support of this field of research. The rumor about elimination of research on photosynthesis seems to be based on anecdotal evidence concerning one or two grants. Because the investigators were very prominent, the entire community was alerted to the fact that their support was being modified, and so the rumor spread. Our investigations show that neither NIH nor NSF is "withdrawing its support for research in photosynthesis or biochemistry" in spite of the statements that have been made to the contrary.

Sincerely yours,

HUBERT HEFFNER,
Deputy Director.

NATIONAL INSTITUTES OF HEALTH—BIOMEDICAL RESEARCH BUDGET DETAIL

[In millions of dollars]

	Fiscal year 1970	Fiscal year 1971	Difference
Overall NIH biomedical research program.....	1,036	1,099	63.0
A. Research grants.....	532	546	14.0
B. Direct operations.....	266	315	49.0
1. Extramural contracts.....	125	165	40.0
(a) Viral cancer program.....			22.0
(b) National Institute of Child Care & Population (contraceptives).....			8.7
(c) National Institute of Heart and Lung Disease (arteriosclerosis).....			4.4
(d) National Institute of Dental Health (caries).....			3.5
2. Laboratory and clinical work.....			8.0

Senator KENNEDY. If Dr. Killian, Dr. Kistiakowsky, Dr. Wiesner, and Dr. Hornig will be kind enough to come up? We want to welcome all of you, gentlemen. I doubt that there is a more distinguished panel of academia than has been assembled here. And all of you have a broad reputation not only for great intellectual and academic service, but also in the public field as well. You have our uniform respect for what all you gentlemen have done for our Nation. We certainly want to thank you for taking the time to come down here and appear before this committee.

Perhaps, Dr. Killian, you would like to make a comment and then I will ask some questions.

STATEMENTS OF DR. JAMES KILLIAN, CHAIRMAN OF THE BOARD OF MIT; DR. GEORGE KISTIAKOWSKY, PROFESSOR OF CHEMISTRY, HARVARD UNIVERSITY; AND DR. DONALD HORNIG, VICE PRESIDENT, EASTMAN KODAK

Dr. KILLIAN. Thank you, Senator Kennedy.

I welcome this opportunity to speak in behalf of an increased appropriation for the National Science Foundation. Those of us who have responsibilities for the financial soundness of our universities and colleges, and for the vigor of our science and technology, come to this hearing with a great sense of urgency. I have been in college administrative work for 30 years, and I recall no time when the financial outlook was so bleak as it is today. We are caught in a vise between inflation and fund cuts, and we fear an unprecedented financial crunch.

A series of Federal actions, each of which might have seemed reasonable within the narrow and isolated context it was decided, are now having a cumulative effect which threatens to be very damaging. Taken together, these actions progressively can curtail the amount and quality of basic research. They can diminish our capacity to educate scientists and engineers. They threaten to discourage young people from electing science and engineering as fields of study. They threaten the breakup of experienced teams of talented scientists and the closing of facilities. They threaten to erode the preeminent position of the United States in science and technology.

These Federal actions include impending cuts in research funds in a number of the agencies, including section 203 of the Military Procurement Authorization Act for 1970; abrupt changes in Federal student-aid programs, such as the cutback in the National Science Foundation's traineeships; the reduction of the National Defense Education Act graduate fellowships and of the National Institutes of Health, which may be phased out; the cost-sharing requirement adopted by Congress as a result of the elimination of statutory indirect-cost limitation; the phasing out of the NASA traineeship program and the sustaining university program which is now underway; the expenditure ceilings imposed on the National Science Foundation; NIH's negotiated reductions in grants; the possible curtailment of funds for the national defense student loan program; and the administration's proposal for a family income ceiling of \$10,000, above which students could no longer receive interest subsidies—despite continued high commercial interest rates—for guaranteed loans.

It is exceedingly important to look at the additive effect of all of these actions, some initiated by Congress and some by the executive branch. The total impact of these independent, unrelated actions is not only affecting the level of funding available, but it is introducing a high degree of instability and uncertainty in the conduct of research and in its fiscal planning. It is eroding the carefully nurtured partnership of the Federal Government and our universities which has been so spectacularly successful over 30 years.

I recognize the desirability of a careful review of the Federal science program and the need for belt-tightening. It is appropriate to re-examine priorities and we certainly need more research funds available for environmental problems and all that has to do with the improvement of our society, and there are certainly opportunities to improve research management and to make adjustments to changing national goals. I salute efforts to tighten up our program, but I submit that an accumulation of uncoordinated actions and uncertainties have brought disorder and dismay in the house of science.

The National Science Foundation has a very special role to play in helping to ease this present crisis. One of its particular functions, I suggest, is to aid in stabilizing our national science program and to help fill the gaps that occur when different agencies of Government change their policies and funding practices. I speak with emphasis of the Foundation's great opportunity to serve as a balance wheel in smoothing the ups and downs in our national basic research budget. I emphasize, too, that, in the past, the NSF budget has not kept pace with inflation, with the result that there has been a net reduction in the number of scientific programs that can be supported.

It clearly has a special role to play now. There have been cuts in R. & D. budgets of several agencies and departments, including Defense. The effects of section 203 of the Military Procurement Authorization Act for 1970 place constraints on the funding of basic research by the Department of Defense, and the spirit of this section 203 may influence other agencies, which are mission oriented, to limit their support of basic research. While I am sure that the arguments in favor of the Mansfield amendment seemed very persuasive when that amendment was looked at alone, that it raised an important issue, and that the time was ripe to reexamine the impact of the Department of Defense on our universities, the existence of that amendment may still be troublesome because so far no compensatory actions have been taken to replace the funds from DOD that it may cut off.

I hasten to add that general cuts in the DOD research budget may be, in their total effect, more serious than section 203. Now is the time, then, for the National Science Foundation to be permitted to exercise its stabilizing role by having funds made available to it to offset the cutbacks resulting from section 203. I also favor giving NSF responsibility for more, but not all, the Government's basic research.

In addition to helping to compensate for the research drop by the mission-oriented agencies, it is important, in my view, for the National Science Foundation to be permitted to continue its traineeship program, which I understand may be phased out beginning in 1971.

Of the various types of Federal financial aid, traineeships are the most valuable since they are awarded by the institution directly to the student without any necessary screening by a selection committee in

Washington. Because of this method of award, it is possible for the university to select from its entire enrollment those students who are most outstanding. Evidence of real ability comes as much from performance on qualifying examinations and the research laboratory as from grades and courses. Hence the faculty supervising the individual student has more valid criteria of excellence than does a selection committee in Washington. In our experience at MIT the graduate students on traineeships are scholastically in the very top rank. So I can't stress too much the importance of continuation of the traineeship program.

Of our 3,400 graduate students at MIT, about one-quarter are engineers supported by Federal fellowships and traineeships. The National Science Foundation traineeship program is one of the most important of this type of Federal aid, with 141 traineeships available to graduate students at MIT for the 1970-71 academic year.

The National Science Foundation traineeships are not the only Federal fellowship program affected by cutbacks, and there will be an appreciable decrease in overall fellowship and traineeship support available to universities in 1970-71. The impact of this decrease in Federal fellowships and traineeships will be felt most keenly by the private universities, which emphasize graduate education.

I also urge some increase in NSF's program for educational innovation and for research to improve the teaching of science.

In supporting an increase for NSF, I must at the same time point out that we in the universities are troubled by some of the restrictions which apply to NSF grants, restrictions such as cost sharing, fixed indirect expense rates, and the matching of faculty salaries. If all DOD basic research were picked up by NSF, the universities would still be in trouble because of these restrictions which do not apply to DOD grants.

While I understand and respect the reasons which prompted the section 203 amendment to the Military Procurement Authorization Act, I find myself deeply troubled by its potential consequences for the DOD and other mission-oriented departments of Government. I have been in a position for many years to observe the interplay between the Government's mission-oriented agencies and the civilian scientific community, particularly the universities. In my judgment, this has been a mutually beneficial relationship, with the benefits greatly outweighing the difficulties. All the mission-oriented Government agencies, including NASA, the DOD, the Atomic Energy Commission, and the National Institutes of Health, need to have close relationships with civilian basic research, and, in turn, civilian scientists and engineers need to be kept in close contact with the missions of these agencies so that there can be a pool of informed scientists and engineers to be of help when needed.

In addition, close relationships between mission-oriented agencies and basic research in the universities can help to provide relevant standards of scientific performance for the in-house research activities of these agencies. I feel strongly that in the long run it would be damaging to the mission-oriented agencies to isolate them from basic research and to deny them these kinds of relationships with the research community. I feel it of vital importance to maintain national policies which call upon the mission-oriented agencies to fund their proportional part of the Nation's basic research.

I would also add that these mission-oriented agencies, notably the DOD, have supported research in our colleges and universities with a perceptive understanding of the best values of science and of the importance of the freedom and independence of these institutions.

Thank you very much.

Senator KENNEDY. Thank you very much, Dr. Killian.

Dr. Kistiakowsky.

**STATEMENT OF DR. GEORGE B. KISTIAKOWSKY, PROFESSOR OF
CHEMISTRY, HARVARD UNIVERSITY**

Dr. KISTIAKOWSKY. Mr. Chairman and members of the subcommittee, thank you for inviting me to testify before you on the subject of the fiscal year 1971 National Science Foundation budget. I believe, and I shall try to justify this now, that the allocation of funds to NSF in the President's proposed budget is not adequate and should be increased.

To understand fully the current status of Federal financing of basic scientific research, which is done largely in our academic institutions, one must place it in the historical context of its evolution since World War II. In the early period after the war, Federal support of basic research came almost exclusively from mission-oriented agencies, mainly Defense and AEC. It was approved by the Congress, as was perhaps most explicitly stated in the statutes establishing the Office of Naval Research and Atomic Energy Commission, because of the conviction that basic scientific research is relevant to the technology-based practical missions of these agencies. The relevancy was regarded as sufficient, although the outcome of any individual piece of research is unpredictable and may have only abstract value, because any continuing broadly-based research program is virtually certain to result in some discoveries that could be practically useful and important if properly developed. Therefore, these agencies allocated their appropriated research funds among the broader fields of science according to each agency's assessment of their relevancy to its mission.

Within each field, however, the individual investigators were chosen for support with the help of outside expert advice, largely on the basis of their scientific excellence rather than because of any direct and apparent relevancy of their work to practical missions. This broad interpretation of the concept of relevancy of extramural research was subsequently adopted by other technologically-oriented agencies dealing with civilian problems. The results of this policy have been of great mutual benefit to the practical missions of the agencies, as well as to science and civilian economy.

The flourishing of the American science into world-leadership role is too well known to require elaboration now. What needs to be emphasized perhaps is the less well recognized origin in academic science of so many newer technologies developed by the Government and by the civilian industry. The list is a long and impressive one.

For instance, it was the leadership of such academic individuals as von Neumann and Aiken which is largely responsible for the concepts of the modern digital computers and hence for a veritable management and industrial revolution. Not being an economist, I can only surmise that the extra taxes which the Federal Government has

collected from computer-based industries have exceeded by far all Federal expenditures in support of academic research in physical sciences.

While the application of the enlightened concept of relevancy that I described has been in general highly successful, the support of some fields of science by mission-oriented agencies was being neglected. An example with which I am especially familiar is that of chemistry. Advances in chemical research are essential for progress in many other technical fields, from experimental solid-state physics through many aspects of environmental sciences and on to agricultural sciences, pharmacology, and the studies of the living cell, especially on the level of molecular biology.

Furthermore, academic chemical research, as was especially clearly shown in the 1965 report on chemistry, sponsored by the Committee on Science and Public Policy of the National Academy of Sciences, has been the origin of a wide range of modern products of chemistry industry. It is disappointing that this aspect of the report on chemistry received no publicity while the unfavorable conclusions of Project Hindsight to which I will come later did get much publicity.

Chemical research has been supported by a number of mission-oriented agencies, but none saw chemistry as central to their mission and so the support was spotty. In this situation the intervention of the National Science Foundation, which is dedicated to encouragement of science for general public welfare, became indispensable, providing the core of the Federal support of chemistry, as the Foundation has been doing for several other scientific fields. Thus NSF has become the central and essential, although fiscally comparatively small, component of the complex operation by which the Federal Government nurtures scientific research and transfers its results into practical applications.

One of the many unfortunate consequences of our misguided and still continuing involvement in Vietnam has been the extreme shortage of funds for domestic civilian needs. Among these needs, if the long-range welfare of American people is considered, the funds for scientific research and the development of new technologies should be given high priority. It is my opinion that optimally these funds should be divided between the NSF and several mission-oriented agencies in order that the largest possible part of the Government would benefit from interactions with the scientific community and so that discoveries due to scientific research would find speediest and most effective applications. Long industrial experience has shown that intimate coexistence between research and development is needed for this.

Unfortunately some other factors besides the Vietnam war have also operated against the continuation of broad scientific support by mission-oriented agencies. A key event was the publication of the Project Hindsight report by the Defense Department, which in effect contended that the contributions of extramural basic research to the examples of military technology considered were not significant.

A closer examination of that report suggests that the conclusion was the result of rather arbitrary and even biased evaluation procedures and judgments. In any case, however, this report which received wide publicity induced unfortunate doubts about the desirability of

a broad support of basic research by the Department of Defense. Subsequent to Project Hindsight report, some serious and probably valid criticisms of certain social-field studies were raised in Congress and treated as part of the problem of support of basic research. All these and other misgivings were given an expression in section 203 of the fiscal year 1970 Military Procurement Authorization Act which sets up much narrower criteria for the required relevancy of research to agency mission than have been in force heretofore.

I do not think that the implementation of section 203 to date has been helpful either to the Defense Department or to American science. An equally unfortunate trend can be discerned in the actions of other Federal agencies which, being pressed by the restrictions of the budget, and possibly applying the sense of section 203 to themselves, have on their own initiative been cutting support of scientific fields less central to their missions. This result of general budgetary stringency and collective pruning has been highly damaging, certainly to the field of chemistry and probably to other fields.

We, as a nation, face now the possibility of unbalanced scientific activities and production of scientifically trained personnel which will have most unfortunate consequences for our economy and general welfare some years hence.

I believe that a close coupling of mission-oriented agencies and extramural programs of basic scientific research is highly desirable and should not be damaged by narrow definition and interpretation of the relevancy of basic research. However, in view of the actions that have been taken, the only feasible immediate remedy for the resulting unfortunate situation is not to be concerned with other agencies but to provide additional funds to the National Science Foundation. These can fill the gaps left by the actions of other agencies and generally sustain the quality of American scientific research in these difficult times.

I fully support, therefore, the first step in this direction—the proposed increase in the fiscal year 1971 authorization legislation for the National Science Foundation.

Thank you very much.

Senator KENNEDY. Thank you very much, Dr. Kistiakowsky.

Dr. Hornig?

STATEMENT OF DR. DONALD HORNIG, VICE PRESIDENT OF EASTMAN KODAK

Dr. HORNIG. Thank you, Senator Kennedy.

Mr. Chairman, members of the subcommittee. First of all, I should like to thank you for giving me the opportunity to present my views to you. The subject with which you are concerned, the activities of the National Science Foundation, deserves the most careful consideration and strongest support. The budget proposed for NSF by the President is, in my view, quite inadequate to meet our current needs.

Because those activities, chiefly long-range research and education in the sciences, have their chief impact on the future rather than the immediate present, they are sometimes regarded as luxury items which can be deferred in a time of budgetary stringency. This, I would emphatically assert, Mr. Chairman, is not so.

We have to be concerned about our future because most of our immediately urgent problems will continue to be with us in the future; some will get worse. If we do not plan wisely for the future, we will be in no better position to solve our problems than we are now, and the new generation will have no new tools to bring to the task. For this reason, it is critically important that we build an adequate foundation of knowledge, skill, and trained people to deal with both the problems we can foresee and those we cannot.

The only alternative to knowledge is ignorance, and too often we are forced by circumstances to proceed from ignorance.

Since the National Science Foundation affords us an important means to prepare for the future, it is imperative that its programs be adequate to the need. That is the question to which I should like to address myself.

Yesterday, for example, was celebrated as Earth Day. We were inundated with speeches, symposia, and conferences which made it clear that we are in danger of overwhelming the fragile environment of this unique planet; indeed, that we have already degraded it almost to the point of no return. What about remedies? Many of them can be carried out now—new sewage disposal plants, new incinerators, modified industrial practices—but at great expense. Other remedies we know in principle but to be useful we need research to cut costs, either directly or by providing substitute processes or materials. Here I have in mind the economic removal of sulfur dioxide from stack gases, for example, or the development of detergents containing much less phosphate. These are research problems which can be tackled in industrial research organizations or in laboratories devoted directly to the environment. But their work must be based on what we know of chemistry, physics, and biology, and many “practical” projects will soon reach a dead end because we don’t know enough basic science.

The job of the NSF is to take the next step. It is to build up the pool of knowledge and understanding so that industry and the mission-oriented agencies of the Federal Government can carry out their tasks.

This is understood by industry, Mr. Chairman. A company which hopes to grow and prosper carries out research directed toward new products and better ways of making them. This is usually done in laboratories attached to the various manufacturing divisions. But it also recognizes that if it is going to prosper a decade hence it has to improve its “kit of tools” and add some new ones. For this purpose it usually maintains a central research laboratory whose job it is to make new knowledge and skills available. This is often from 10 percent to 25 percent of the total effort, and industry does it because in the long run it pays.

This is also the case in the Federal Government. Agencies like HEW, HUD, Transportation, Agriculture, Interior, and so on, have recognized the need for research which will make it possible to do their jobs intelligently and at lower cost.

Further than that, the more farsighted agencies have recognized that when solutions aren’t just around the corner they have to lay a broader base by doing exploratory research which goes farther afield. This is the sense in which DOD has supported academic research in electronics: for example, not to assist in the design of

weapons needed now but to provide a general capability for the future in a field which is believed to be important to defense. It will also contribute to the general welfare.

In the same way, the National Institutes of Health support work in the basic physiology of cells, so that in the future diseases can be eradicated more efficiently by cause and effect rather than trial and error.

This is as it should be. But the trouble is that, particularly under the pressure of a tight budget, the programs of the agencies are tending to be too narrow and too short range. This tendency has been accelerated by such actions as section 203 of the military procurement authorization bill. In any case, there are many areas of research and manpower training which benefit many agencies, not just one, and we would not want work in them duplicated needlessly.

The National Science Foundation is the central research organization of our Government. It is the core which supports the development of science as a whole, providing an underpinning to the more directed efforts of the agencies. This role has been accentuated by the reductions in other programs, such as the NASA and NDEA fellowships programs.

You may ask, "Why not focus on those things we need to know?" The answer, of course, is that we only know afterward what we need to know, and it may come from the most unexpected quarters. I have tried to imagine myself a perfectly wise director of NIH about 50 years ago who wanted to speed up the medical revolution which has taken place since World War II. To be specific, what would he have had to foresee to advance the discovery of DNA and how it determines heredity? He would have had to develop the physics of X-rays and crystals so that 20 years later they could be applied to complex biological molecules. He would have had to develop the mathematics which made the calculations possible. He would have had to develop the transistor and integrated circuits, as well as the design of computers. He would have had to back the physical chemistry which made it possible to separate pure specimens of these substances.

In fact, if you trace all the branches of this tree, he would have had to support just about every branch of modern science.

The same is true of most important practical steps. They have their roots in many places which could not conceivably have been foreseen.

I had thought the Congress and the country understood this when it established the National Science Foundation. Certainly it was a successful venture and for 15 years it prospered. It played a central role in making fundamental science in this country the best in the world; it helped develop strong university centers whose graduates staff industrial and Government laboratories and provide us with teachers for the next generation.

Now that has changed. When the Congress cut the NSF fiscal year 1969 budget by 20 percent 2 years ago and kept it at a lower level last year, this development was reversed. The effects did not show up immediately because of forward funding, but now they are clear and evident. Graduate centers throughout the country are having to curtail their activities. The cutback is not just in the quantity of

work; they have had to curtail the bold new explorations which are the heart of scientific advance. The problem is multiplied because research and training funds are simultaneously being cut in other agencies and their definitions of relevance are being narrowed. An example is the Department of Defense.

Sir, when examining the effect of fund cuts, it is important not to look only at the shifts of the last few months. The problem has been growing for at least 2 years. The budget request for NSF this year is not substantially changed from that in fiscal 1969.

Since 1967 the total effort in fundamental science, including the effect of inflation, has been cut about 20 percent. This is surely short-sighted at a time when our problems, such as those of health or the environment, are becoming more subtle and place greater demands on new knowledge and on the availability of people trained in problem solving.

In my view, the present budget for the National Science Foundation is inadequate to the needs of the country. It cannot take over the high-quality projects which are being abandoned by the Department of Defense or the National Institutes of Health. Nor can it act as the organizational center of scientific development and be the agency to grasp new opportunities as they appear. It can at best hang on, and I predict that in a decade we will pay dearly for these economies now.

Therefore, I hope this committee will not only authorize the amounts requested in the President's budget but add the capacity for the National Science Foundation to assimilate the high-quality programs other agencies must abandon as they focus their programs more narrowly. It is peculiarly suited to the job of making the best use of scientific resources in universities when money is tight, through programs to even out the extreme ups and downs which add to the crisis of the universities.

The most important resources for the future will be knowledge and understanding, and people possessed of both. It would be irresponsible of us to save a pittance now at the expense of those precious resources.

Thank you very much.

Senator KENNEDY. Thank you very much, Dr. Hornig.

Dr. Weisner?

**STATEMENT OF DR. JEROME WIESNER, PROVOST, MASSACHUSETTS
INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.**

Dr. WIESNER. Senator, I don't have a prepared statement. I have made some notes. I would like to emphasize some of the points that my colleagues have made here.

First of all, I think the theme that goes through this is that the scientific establishment is in considerable trouble. It can't be overstated. Dr. Hornig said that the funding problems we are wrestling with go back 2 years. I think they go back actually 4 years or thereabouts.

We have been living with essentially constant dollar levels with possibly some cuts in some agencies and some increases in others. But when one adds the inflationary impact to this, then the attempts to do some funding for the new socially relevant fields that we are con-

cerned about and do some new things, like the new high-energy accelerator that the Atomic Energy Commission is attempting to build in Illinois, we find that actually real money available for the scientific programs has been shrinking now for a number of years.

We have often tried to make some estimates of what is required to keep a healthy scientific establishment of the kind we have in the United States viable and growing and able to pick up the great new opportunities as they came along. And I think we would all agree that, in the face of the kind of inflation which we are living with, a 10-percent-per-year increase in research budget would be austere. We have not had anything comparable to that for several years. I think 15 percent per year would be a more appropriate figure.

Now, 10 percent of the NSF budget is \$50 million. Actually we are talking about here adding \$50 million not to keep the programs going but to pick up some programs that are being dropped by the other agencies. So that, even if you are successful in this action, the impact on the science programs this year will be one of contraction and reduction, I believe, and I think we should keep this in mind.

I think this will have some very serious impacts on our Nation in various ways. The long-term impact is sure to be very serious on our economy, if this is sustained. I expect we can live through 1 year and pick up, although there would be some impact. On the other hand, if this is a new trend, I think we must expect that the technological and scientific leadership of the United States will not exist in a decade. The productivity edge which technology has given us and which allows us to compete worldwide with our products because of the technological supremacy that we have—because of the productivity edge that we have—will just not exist and we will find ourselves in a very serious economic difficulty.

The shortsightedness of this I think can be seen when one considers the facts of the case. Somebody recently estimated that the total expenditures for fundamental research from Archimedes to the present time amounts to about \$25 billion. This is just, by coincidence, I suppose, comparable to the money that we will spend on the lunar programs. If one adds up all the things that one can conceivably call academically oriented research, we get a sum of money per year of something under \$3 billion a year to be supported by a gross national product of about \$800 billion a year; a gross national product which would critically be very much smaller than that if we did not have the science-based technology on which we built our economy.

Many of the people think this is all in the past and we can rest on the knowledge we have. As has been said several times already here, that is not true. There is much more ignorance in most fields of science than there is knowledge, and much to be gained by maintaining a continuing forward thrust of our activity.

The sad impact of the kind of restrictions that we have been talking about is that just the exciting new gambles are the things that get cut first. For example, there are very few new instruments being developed in this country, whereas a decade ago, or even 5 years ago, the United States probably was the best instrumented, best equipped scientific nation in the world. That is no longer true today.

In the field of high-energy accelerators, for example, it is not true. It will not be true in the field of radioastronomy. In many other fields we find one nation or another, by concentrating its resources,

is moving out ahead. We, for example, are not able to fund—continue to support—many of the high-energy physics programs that the Atomic Energy Commission has been carrying on in our universities. Because the beginnings of the research program for the new accelerator—we have begun to build the accelerator and therefore we have to have a scientific program to go with it—has had to be funded out of the constant-level research program and to find that money a number of programs have been either stopped or cut back drastically. This has been exacerbated by the DOD action in response to section 203.

I can go through a number of fields of science where this impact has occurred. I am talking here about the longer term impact on our economy which I don't think you can reverse, once it is set in motion. There will be a shorter range or serious impact that Dr. Killian talked about, and that is the very serious impact of these changes. Major changes in policy carried on one at a time by agencies without consulting together and without really trying to assess the total impact are going to have a devastating effect on the American university scene.

Universities are already in trouble. Inflation, the need to pick up new programs, the effort that universities have been making to deal with their community problems, their black-education problems, and so on, have all been very costly. And when one adds to that the very sizable impact of the research cuts, I think we are going to see many universities having to drastically curtail their educational programs, or look to the Federal Government or State government for emergency support.

We have seen some of that already. I predict the impact of some of the things we have been talking about here is going to bring a number of major universities to the brink of disaster in the next 2 or 3 years, if this is continued.

Dr. Killian mentioned the NSF cost-sharing policy. It is carried out in a way which none of the agencies enforce and has a very major impact on the cost of universities. For example, my own university has added in the last 3 years a half million dollars of cost to our research program, which we have had to find from private sources. Every other university, I think, has had to respond in the same way.

One thing which people I don't think fully appreciate is that there are serious leverage effects to these changes. A 10-percent cut in a research budget has a much larger impact on the number of new students that a university can begin to train, because you have students in the pipeline—you can't stop them, you have to deal with inflationary problems—and so across the country we are seeing rather substantial decreases in the number of students which we are being able to admit.

I have seen predictions or estimates that the graduate-student body in the Nation will fall about 10 percent. I am not certain of that. I know our own prediction is that we will be able to support about 10 percent fewer students in the year ahead.

Now, one of the reasons for that is that we have never fully appreciated the broad impact of the technology and sciences the Government has been funding on our welfare. We had a very easy way of funding it for a long time. The defense urgencies and medical urgencies were such that we did not have to relate these things to the other

benefits which the Nation derived. As we have been able to mitigate to some degree the cold war and as we have wanted to turn our medical funds more to health care and less to research, a short-sighted point of view I believe, we have not recognized the long-term necessity of keeping a growing basic-science program for our national health.

So I would suggest, sir, that what you are proposing to do is absolutely vital to keep the establishment from falling apart with what is really not even enough to keep the programs as healthy as I believe they should be to insure our future.

Thank you.

Senator KENNEDY. Thank you very much, Dr. Wiesner.

I think all of you have added immeasurably to the case for an expanded and an increased authorization for the NSF.

I would like to try, if we could, to get your reaction to the increase of \$50 million. As I understand from you gentlemen, you feel this is a minimum figure. Am I correct? Would you go higher?

I would like to add that obviously this judgment has to be made in terms of other kinds of priorities. Certainly all of you have wrestled with this problem. I think your informed, balanced judgment on it would be of value. What we are trying to do is to be able, both before this committee and on the floor, to present the considered judgment of perhaps the most experienced and knowledgeable men on this problem.

I know you have followed the NSF programs closely. You are aware from your personal knowledge and professional knowledge, perhaps in terms of the universities with which you are associated, what the research demands are. Would there be any additional comment you would like to make about the \$50 million increase?

Dr. KILLIAN. I believe, sir, that the \$50 million increase is a minimum amount that we should really get to prevent the kind of baneful effects we have been trying to delineate here. Of course, it depends on what happens to other agencies, too. The situation will remain unstable and uncertain without that order of increase.

Dr. KISTIAKOWSKY. It seems to me, Mr. Chairman, that when we are assessing the effect of the \$50 million we have to consider that the total research support in universities, and I am using NSF figures, is of the order of \$1.5 billion a year. There has been a real drop in these appropriations due to inflation and also due to the recent creation of many new university-type institutions in the parts of the country where they didn't exist before. The real drop is at least 20 and more likely 25 percent in the last 4 years, the figure which Dr. Hornig and Dr. Wiesner spoke about. That is \$400 million decrease in a \$1.5 billion appropriation.

Seen in that light, \$50 million is a very small amount. I think it is completely vital to have that increase and it will be probably just about enough to take care of the really unfortunate pruning that was done in the spirit of section 203. It resulted from fear that research was being supported which may be first class but was not quite justifiable as directly relevant to the agency's mission.

Dr. HORNIG. Senator, I think that \$50 million is commendable but probably inadequate. One should look a little bit at history. I don't have any detailed figures at my disposal, but as I recollect the appropriation to NSF in fiscal 1968 was something like \$480 million. The

budget request in 1969 was \$500 million which, excepting sea grant, is the same as this year. Considering inflation in the meantime, there has been an effective cutback in requests. The fiscal year 1969 request was cut back to \$420 million by Congress and the fiscal year 1970 increase was very small. The interesting thing is that the severe impact of cuts up to now has not been felt so badly because NSF had something like \$600 million involved in the forward funding of research. As a result expenditures in the last 2 or 3 years were considerably in excess of the appropriations. That simply meant that we were living on that capital of forward funding. This can't be kept up very long.

Senator KENNEDY. What do we have in terms of capital now?

Dr. HORNIG. I don't have that. NSF would have to supply you with that. Obviously the amount of forward funding has been dropping severely. The accumulative effect of several years is finally catching up with us.

The fact is that, in the face of inflation, all through the Federal Government the basic research funds were substantially constant over a period of 4 years and have literally dropped in the last years, so that the total national effort has dropped.

The third point I would make is that a relative effort ought to be concentrated in NSF in time of stringency because it is the only agency, when one considers the health of the universities, that can look at the total effect, without the constraints of narrowly defined missions, the total effect on university departments and on university structures. I know that when I was in Washington the problem of how to move any money around to smooth out the drastic effects that you have, when some things come to a stop and other things grow, was very difficult. This sort of chaos was very difficult to cope with.

On the other hand, if NSF controlled a reasonable fraction of the expenditures in the universities then the problem could be managed.

I should think a third reason for increasing the expenditure in NSF is that it is better able to cope with a fiscal situation in time of monetary crisis.

Senator KENNEDY. That is a helpful comment.

Dr. Wiesner.

Dr. WIESNER. I don't think I will repeat my statement about the absolute values but I would disagree just a little bit with Don Hornig that the effects aren't visible. They are not visible in terms of the number of people, although last year there was a drop in graduate-student enrollment in the sciences. If one looks at the strict sciences, for example, three fields that I know very well and that I am involved in, radioastronomy, the computer sciences, and mathematics generally, these fields have been badly slowed down for several years because of the inability to fund the new opportunities that arise and which always arise as you do research.

So I think the programs in these areas have had several years of austerity, several years of being slowed down from what would have been a normal and rational program in an ordinary funding situation.

Senator KENNEDY. I am wondering if we could probably get some figures showing the decline in those fields, Dr. Wiesner, perhaps from MIT and Harvard. I think what we would also like to do is get the figures nationally and perhaps from NSF.

Dr. WIESNER. I think what you would want to get from NSF is not a decline. There has not been an absolute decline in funds but what they can show you are things which they would ordinarily think are important and even vital to do in these fields which they have not been able to support. NSF has a plan for radioastronomy and for visual astronomy which will involve new instruments which we will need.

For several years they have been developing those instruments because they can't afford them. AEC has had to close down some of their higher geophysics establishments. I think that, given the funding, they made the right decision. I am not criticizing the specific decision they made, but I am saying that it has had a major impact on those fields and I think those agencies could tell you that.

Senator KENNEDY. What I would like to do is get the change in the number of graduate students, in terms of mathematics and some of the other areas.

Dr. WIESNER. Right.

Senator KENNEDY. Dr. Killian, you mentioned in your formal testimony six or seven different areas where cuts have been made, in NASA fellowships, because of the Mansfield amendment and so on.

I am wondering who bears the responsibility to coordinate all of those cuts and to really tell us their impact. I thought you listed very effectively, in a way which I had not really heard before, a number of these programs and when they are considered in their totality it indicates a very dangerous kind of trend.

Is this sort of thing coordinated by the President's scientific adviser? Should NSF do this? How do we really find the total impact of these kinds of cuts on the scientific community?

Dr. KILLIAN. I would suggest in the executive branch there are two places where this particular picture ought to be looked at and delineated. One certainly is the National Science Foundation, which has a policy responsibility to look at this total picture. I would also suggest the Office of Science and Technology, Executive Office of the President, very definitely ought to be presenting this total picture.

The effects of all these cumulative actions have been largely unrelated.

I also would hope that there are ways in Congress itself to look at this total picture. I think, fortunately, we have hearings of this kind that serve to bring out the overall picture. It seems to me such committees as, for example, the House Committee on Science and Astronautics, which has been looking at this, can very well definitely display the whole picture, and committees of the Senate such as this one also can do that.

Dr. WIESNER. It is my impression that in the reorganization of the National Science Foundation which was carried out a few years ago they were given the responsibility for coming to the Congress with an annual report on the status of science.

I am not sure they have interpreted it to mean just the kind of report you are asking for but I would suggest that it should mean that.

Dr. KILLIAN. I would like to reemphasize the fact that all of the separate actions, unrelated when they were taken and uncoordinated, are what is causing the severe problem that we have today.

Senator KENNEDY. I think your testimony on this point is extremely telling. We have examined some of these points individually, but collectively I think it is really extremely distressing.

Dr. Kistiakowsky, what do you and all you gentlemen feel is the attitude of the graduate student, the young person who is moving into the science field? Do young scientists see the results of the downgrading of science and has this affected them in both the short- and long-range term?

Dr. KISTIAKOWSKY. Yes, they certainly do. It is a complex situation. Some young people have been influenced by the modern ideas that science is not helpful to human welfare and so they talk about moving out of pure science and into social science. There are these few but I have had also other individuals come and talk to me and let their hair down—even MIT students—and the much more common reaction is one of doubt about their own future, doubt about the real value of intense concentration on science in the face of the governmental and public attitude toward science which is not as favorable as it used to be.

I think that most of the young people now in school and the young instructors in colleges have, shall I say, very much lower job expectations than their predecessor had 5 or 8 years ago.

Dr. KILLIAN. May I answer this, that I think a very important factor here is the reaction of the young people, undergraduates who are thinking of going on to graduate study, to the cuts and constraints and problems that they see ahead which tends to discourage them, to give them the feeling that the opportunities are going to be meager.

Let me add one thing to second what Dr. Kistiakowsky said. I think it is unfortunate that there is an effort to make science and technology a scapegoat at the present time for all our social ills. I think we are not going to solve the pollution problem, our environmental problem, without a more concentrated application of sciences and technology, and we are going to need more scientists and engineers to deal with this problem.

Dr. KISTIAKOWSKY. May I associate myself with that? I am 100 percent in agreement with Dr. Killian.

Senator KENNEDY. Let me ask this question: There was brought out in testimony the importance of the continued research for private industry and private enterprise. Do you see the Government cut-backs that are being talked about spilling over to affect the private sector? What is the relationship to the private sector? Is there a relationship or do we find that most of the private groups in industry are doing their own thing and that therefore what happens at the Federal level is not so significant?

Dr. HORNIG. It happens that the Federal level is critically significant. Approximately half of all the research carried out in industry is funded by the Federal Government. Of course this does not involve the National Science Foundation directly, but the cuts in other agencies are significantly cutting the amount of research done in industry.

Now private expenditures for research in industry have been rising at the rate of 7 percent per year, but the total private expenditure in research and development in the last year was approximately \$7.5 billion, although I would have to check that figure. In basic research, the industrial part is only a very small part of the total.

Dr. WIESNER. One thing which is not always fully understood is that our industrial corps depend on the universities' basic research. There is very little basic research done in industry as compared to that provided by the universities. So that the Nation's entire technological enterprise, whether it is for the Government or for private industry, rests on the fundamental science that comes out of the universities.

Senator KENNEDY. Do the industry groups realize the significance of these cuts? Are we going to be able to get some help from them in terms of support for restoration of funds, or is this still pretty unclear to them.

Dr. HORNIG. I think it is complicated for the following reason: Of course, the effect has varied very widely by industries. Some industries have had very little interaction with Federal funds. Some a lot. Some of those directly affected have reacted already. More fundamentally, though, during this last year industry has been a little bit confused because in a certain sense we have never had it so good. As other job opportunities have declined the first superficial effect was to make more highly talented people available than at any other time in modern history.

However, in the last months a number of industrial people I know have been getting in touch with each other to ask themselves precisely that question: What can we do because surely this is going to hurt us in the long run and probably in the fairly near future?

Dr. KILLIAN. Groups like the Council for Financing Higher Education, which is largely a group representing business and industry, have been pushing very hard to get an increase in corporate grants for support of basic research in universities.

Senator KENNEDY. One of the problems is this: I know up at MIT there has been the considerable controversy regarding DOD's support of research at the university and the wider issue of converting defense industry R. & D. to civilian areas. I would be interested in your appraisal, Dr. Wiesner, and perhaps Dr. Killian, on what these problems are and your reactions as to what is going to take place.

Dr. WIESNER. They are complicated problems for us, of course, because I suppose MIT has this problem as acutely as any other university. The University of California, and a number of others, of course have similar problems. We have operated at MIT two large laboratories for the Defense Department. These are not part of the academic program; these are things that we undertook a great many years ago in times of national crisis for the Defense Department and which I believe should be continued for the Nation. I don't think that my views on the arms race have to be spelled out here; I think it should be stopped. But I think, until we do find good, alternate security the Nation does have to continue its research, which is the underpinning of our national security. This is one of the reasons why many of us feel that section 203 can do great damage to the Defense Department and hence to national security. Whether or not it is appropriate for universities in a more tranquil period to be operating institutions of this kind is something that we are working on very hard, and we suspect in the years ahead we will want to change relationships with regard to this.

Now there are other forms of DOD-sponsored research which are a more common problem in all of the universities, and that is the kind of research that section 203 relates to, basic research sponsored by the Office of Naval Research, aerospace research, and the Army in order to have a good continuing flow of fundamental science for the Defense Department, and in order for the people who are involved in applying it to the Defense Department to have associations with fundamental science, the DOD has always supported a good deal of basic research.

Here again I believe most of us believe it would be a mistake from the Nation's point of view to discontinue that. I think there is a general feeling—I suspect we would get agreement here on the panel that the balance ought to be shifted somewhat.

I personally have felt that the National Science Foundation's share of the total support of fundamental science in the country has always been too small. When I was involved in trying to help formulate national policy I had a goal, which we never came close to, of trying to see that the National Science Foundation budget amounted to about 30 percent of the national research effort; this despite not only the bigger share of what the DOD may be doing but also some of the things that are now done by the AEC and by NIH and other agencies.

So that I do think there has to be a shifting emphasis here. But I do think that we should not allow ourselves to be panicked into making moves which are destructive of our national security in a period when we still, I think, are going to have to depend on science and technology for its underpinning.

Senator KENNEDY. How ready would the laboratories at MIT be to move into some of the social science problems?

Dr. WIESNER. First of all, there is, I think, a considerable misunderstanding about what these two big laboratories are already doing. For example, the instrumentation lab which has been doing the guidance work for 15 or so years for our ballistic missile program has at least half the program in nondefense activities. For example, it has done most of the guidance and control for the Apollo program. It is involved in some research and development work on transportation.

Lincoln Laboratory has been involved in air navigation work, about 20 percent of its programs are not directly defense-related. I think we would welcome the opportunity, and have in fact been seeking the opportunity, to increase the socially relevant things. The people in these laboratories have a lot of capability and are very anxious to add them to the capabilities that are working on the social problems. One of the difficulties, of course, is that while we have had a tremendous amount of rhetoric about doing something about these problems, we don't have the funds. There is not very much money to do research in the urban field or on transportation or on pollution.

One of the difficulties of a day like yesterday is that we get everyone fired up about doing something and then there is nothing left to do afterward but think about it, because the resources to do effective work do not exist.

Senator KENNEDY. I take it all of you agree on the traineeship program and the importance of it.

Dr. WIESNER. Yes. I disagree with the statement that was made about the relative value. I think we all think the fellowship programs are important, but we also believe the trainee programs are important for two reasons: First of all, for the institutions that might attract students anyway, traineeships allow you to balance your programs and to have coherent programs so that you are not totally at the whim of the students' decisions. We can then plan our departments and programs for some years. I think that is very important. It is particularly important when you are trying to create new programs.

For some of the smaller institutions, I think they are vital or they won't be able to attract those people. The thing I would not want to speculate on now is what the balance should be because I have not thought about it hard enough. I think it would be a bad mistake to phase out the traineeship program completely.

Dr. KILLIAN. May I add to that by emphasizing the need for all forms of student aid, which includes fellowships and scholarships, and loans and traineeships. One by one these different forms of student aid are being cut. They are being cut by Government. They are also being cut by private sources of funds. I think we face a very difficult problem ahead in providing adequate student support.

Dr. KISTIAKOWSKY. I would certainly agree that the ideal arrangement is to have several sources of student support. This is unquestionably the best arrangement. If some rather unfortunate external force forced me to make a choice and left me no alternatives except the choice between a program of national fellowships and the traineeships, I think I would take the program for national fellowships.

Dr. WIESNER. I don't think I would disagree but I don't think that there is such a God-given force working on it.

Dr. KISTIAKOWSKY. Well, some extraordinary forces are at play.

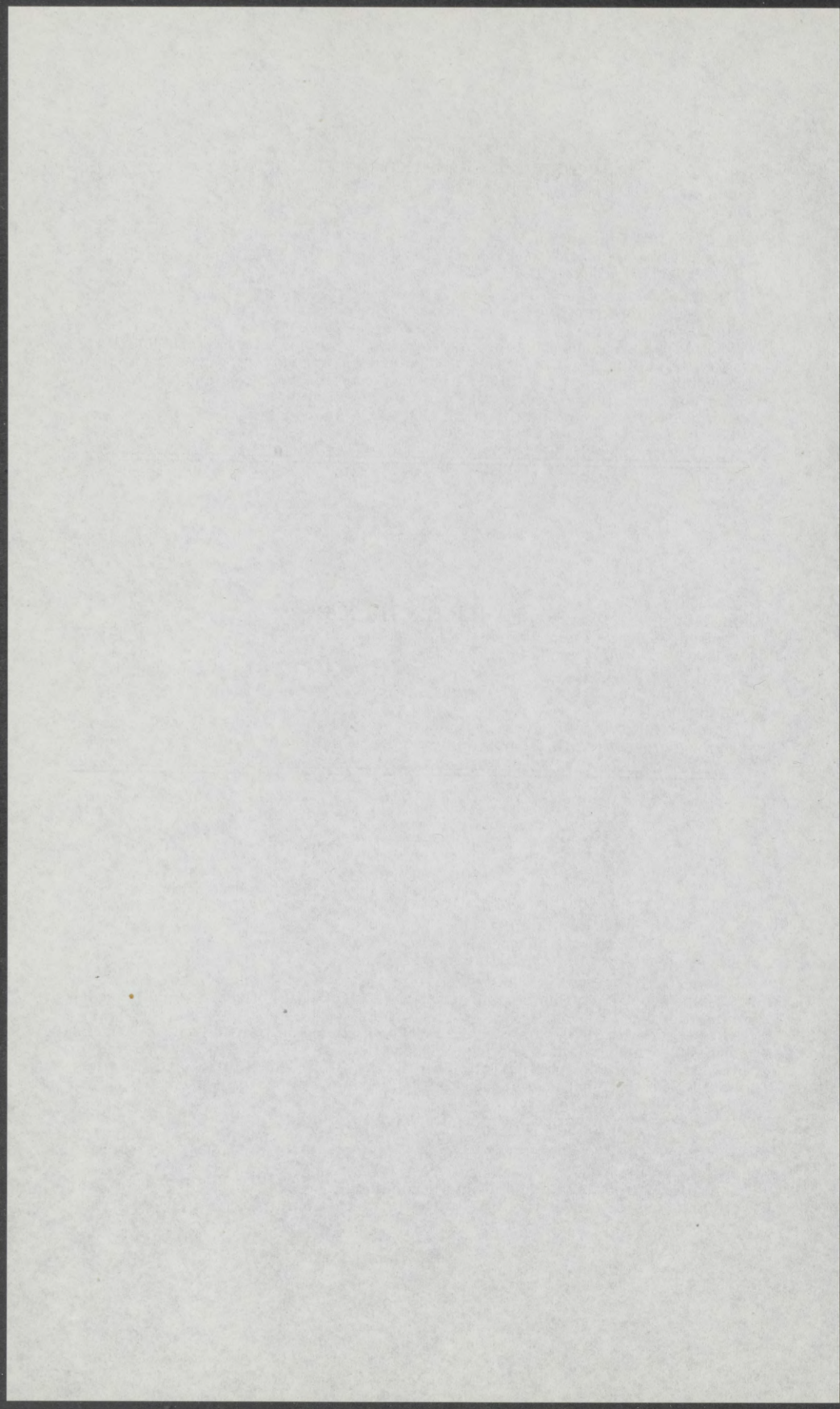
Senator KENNEDY. We are talking about \$10 million in this program. Continuation of the program only requires about \$10 million.

Dr. HORNING. In the end we need programs of two different sorts, one that sets national standards and one that makes institutions viable.

Senator KENNEDY. I want to thank you gentlemen very much for your appearance here. It has been extremely useful and helpful to receive your commentaries on these matters. As we move along I will feel free to be in touch with you for additional kinds of information and guidance, but your comments here are extremely persuasive and I am confident that my colleagues both on the committee and in the Senate will find them so, too, and hopefully we will be able to see an increase in NSF funding. We are committed to make every effort in that direction. I think with your strong support and help it will be a great deal easier and we will, hopefully, be able to give this whole effort in science the kind of priority that I believe you gentlemen feel it should have, a view which I share as well. Thank you very much.

(Whereupon, at 4 p.m., the committee was recessed subject to call.)

APPENDIXES



APPENDIX I.—DEPARTMENTAL LETTERS

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., April 1, 1970.

HON. RALPH YARBOROUGH,
*Chairman, Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in further reply to your request for comments on S. 3412, a bill to authorize appropriations for activities of the National Science Foundation.

The bill would authorize appropriations in the amount of \$498,000,000 for the fiscal year ending June 30, 1971, and such sums as may be necessary for the succeeding fiscal year (plus, in each instance, not to exceed \$2,000,000 in excess foreign currency funds). Such authorization is required by Section 16(a) of the National Science Foundation Act of 1950, as amended (42 U.S.C. §1875).

The Foundation has no objection to the enactment of the Bill as introduced. The Bureau of the Budget has advised us that there is no objection to the submission of this report from the standpoint of the administration's program.

Sincerely yours,

W. D. McELROY,
Director.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., March 24, 1970.

HON. RALPH W. YARBOROUGH,
*Chairman, Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request for a report on S. 3412, a bill "To authorize appropriations for activities of the National Science Foundation."

The Bureau of the Budget recommends the enactment of S. 3412, which would authorize appropriations of \$498 million, plus \$2 million in foreign currencies, for fiscal year 1971, and "such sums as may be necessary" for fiscal year 1972.

Sincerely,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

EXECUTIVE OFFICE OF THE PRESIDENT,
BUREAU OF THE BUDGET,
Washington, D.C., April 29, 1970.

HON. RALPH W. YARBOROUGH,
*Chairman, Committee on Labor and Public Welfare,
New Senate Office Building, Washington, D.C.*

DEAR MR. CHAIRMAN: This is in response to your request for a report on S. 3700, a bill "To authorize appropriations for activities of the National Science Foundation."

On February 2, 1970, the National Science Foundation transmitted to Congress a draft bill which would authorize appropriations of \$498 million, plus \$2 million to be paid in foreign currencies, for fiscal year 1971. The Bureau of the Budget advised NSF that enactment of the draft bill would be in accord with the program of the President.

S. 3700 would authorize appropriations for 1971 of \$548 million, plus \$2 million in foreign currencies, an increase of \$50 million over the amount included in the NSF draft bill. In addition, S. 3700 would authorize appropriations of "such sums as may be necessary" for fiscal year 1972.

The Bureau of the Budget would recommend the enactment of S. 3700 if it were amended to reflect the 1971 authorization amounts in the NSF draft bill.

Sincerely,

WILFRED H. ROMMEL,
Assistant Director for Legislative Reference.

THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and expansion. From a small collection of colonies on the eastern coast, it grew into a vast nation spanning a continent. The early years were marked by struggle and the search for a common identity. The American Revolution was a pivotal moment, leading to the birth of a new nation. The westward expansion of the 18th and 19th centuries brought new challenges and opportunities. The Civil War was a defining event, resolving the issue of slavery and preserving the Union. The Reconstruction era followed, a period of rebuilding and reform. The late 19th and early 20th centuries saw industrialization and the rise of a powerful nation. The 20th century brought global conflicts, social movements, and technological advances. Today, the United States remains a major world power, facing new challenges and opportunities in the 21st century.

The early years of the United States were a period of struggle and growth. The colonies on the eastern coast were the first to settle, and they grew into a powerful nation. The American Revolution was a pivotal moment, leading to the birth of a new nation. The westward expansion of the 18th and 19th centuries brought new challenges and opportunities. The Civil War was a defining event, resolving the issue of slavery and preserving the Union. The Reconstruction era followed, a period of rebuilding and reform. The late 19th and early 20th centuries saw industrialization and the rise of a powerful nation. The 20th century brought global conflicts, social movements, and technological advances. Today, the United States remains a major world power, facing new challenges and opportunities in the 21st century.

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APPENDIX II.—REDUCTIONS BY OTHER FEDERAL AGENCIES IN SUPPORT FOR ACADEMIC SCIENTIFIC RESEARCH

OFFICE OF THE DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING,
Washington, D.C. May 5, 1970.

MR. JOSEPH ONEK,
*Office of Senator Edward Kennedy,
New Senate Office Building, Washington, D.C.*

DEAR MR. ONEK: As per our telephone conversation on Monday, May 4, 1970, I am forwarding to you a general summary of the results and implications of the reviews by the Military Departments and Defense Agencies of all research and exploratory development projects conducted as part of the implementation of the provisions of Section 203 of P.L. 91-121.

The detailed and comprehensive reviews of nearly 15,000 R&D work units resulted in 417 tasks found to be marginal within the provisions of Section 203. These projects represent about \$8.3 million, and will be phased out or not obligated during FY 70. The great majority of those rejected (404, \$8.25 million) were in the 6.1 Research budget category. It should be noted that the FY 70 6.1 Budget request was reduced by \$64 million notwithstanding Section 203, and the amount finally appropriated for FY 70 was \$35 million less than FY 69. Therefore, the \$8.3 million attributed to Section 203 is a minor part of the total research reduction imposed by Congress.

As we have stated before, several difficulties are involved with interpreting and applying Section 203. For example, it can be interpreted to require the DoD to discontinue support for basic research, particularly in the academic community, because it is simply not possible to guarantee relevance of some areas of research long in advance. But we do need a substantial level of imaginative basic research if we are to maintain technical leadership in areas upon which our future national security will depend. Furthermore, discontinuation of basic research in the academic community would deprive the DoD and the country from using the services of many of the best scientists in the nation on defense problems. In the short term, scientists may tend to not even offer proposals to defense problems because they perceive a Congressionally-directed decline in the DoD interest in science. Also, experience has demonstrated that Sec. 203 is difficult to administer because implementation depends upon technical and military judgments which frequently must be subjective. Therefore, we feel that Section 203 should not be included in the FY 71 authorization Act.

Sincerely,

DONALD M. MACARTHUR,
Deputy Director (Research and Technology).

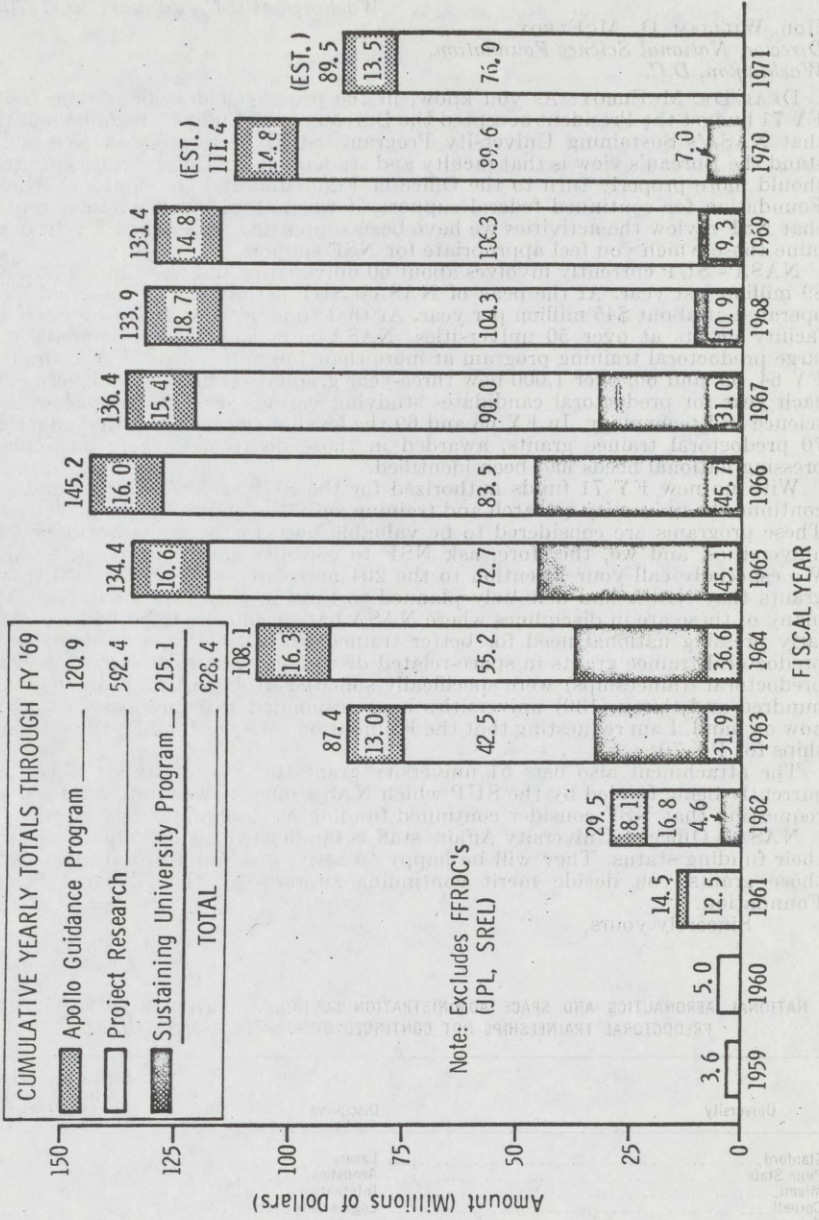
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., March 18, 1970.

HON. EDWARD M. KENNEDY,
U.S. Senate, Washington, D.C.

DEAR SENATOR KENNEDY: At the request of Mr. Joseph Onek in his telephone call to Mr. Francis B. Smith, Assistant Administrator for University Affairs, on March 17, 1970, I am sending you a copy of the proceedings of the February 10, 1970, NASA University Conference. At that conference we presented NASA's proposed future research and flight plans and made available our best information regarding expected levels of NASA-sponsored university research in the coming year.

You will find most of the information Mr. Onek requested on page 27 of the conference proceedings. Obligations to universities in Fiscal Year 1971 are ex-

NASA OBLIGATIONS TO UNIVERSITIES



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION,
Washington, D.C., January 29, 1970.

Hon. WILLIAM D. McELROY,
Director, National Science Foundation,
Washington, D.C.

DEAR DR. McELROY: As you know, in the process of developing the NASA FY 71 budget the President accepted the Bureau of the Budget's recommendation that NASA's Sustaining University Program (SUP) be terminated. We understand the Bureau's view is that faculty and students benefiting from this program should more properly turn to the Office of Education and the National Science Foundation for continued federal support, if warranted. We, therefore, request that NSF review the activities we have been supporting under the SUP to determine those which you feel appropriate for NSF support.

NASA's SUP currently involves about 60 universities and was funded at about \$9 million last year. At the peak of NASA's SUP activities in FY 65 and 66, it operated at about \$45 million per year. At that time, in addition to research and facility grants at over 50 universities, NASA also supported a comparatively large predoctoral training program at more than 150 universities. For example in FY 64, 65, and 66, over 1,000 new three-year graduate trainee grants were made each year for predoctoral candidates studying various subjects in space-related science and technology. In FY 68 and 69 the level of the training was reduced to 70 predoctoral trainee grants, awarded in those disciplines where particularly pressing national needs had been identified.

With no new FY 71 funds authorized for the SUP, NASA will be unable to continue the university research and training activities shown on the attachment. These programs are considered to be valuable both to the government and the universities, and we, therefore, ask NSF to consider continuing their support. We especially call your attention to the 204 new three-year predoctoral trainee grants that NASA had definitely planned to fund in February 1970. Note that many of these are in disciplines where NASA has specifically identified a particularly pressing national need for better trained Ph. D.'s. Proposals for the 150 predoctoral trainee grants in space-related disciplines (last item shown on list of predoctoral traineeships) were specifically solicited by NASA in June 1969. One hundred and thirty (130) universities have responded with proposals which are now on hand. I am requesting that the Foundation consider funding these traineeships for FY 70.

The attachment also lists 61 university grants for various types of research currently being funded by the SUP which NASA must now terminate. I am also requesting that NSF consider continued funding of these university efforts.

NASA's Office of University Affairs staff is familiar with these grants and with their funding status. They will be happy to assist you in an orderly transfer of those grants you decide merit continuing support by the National Science Foundation.

Sincerely yours,

T. O. PAINE,
Administrator.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION SUSTAINING UNIVERSITY PROGRAM—3-YEAR
PREDOCTORAL TRAINEESHIPS NOT CONTINUED BY NASA IN FISCAL YEAR 1970

University	Discipline	Number of traineeships	Planned amount (thousands)
Stanford	Lasers	5	\$112
Penn State	Acoustics	6	135
Miami	International	3	53
Cornell	Engineering Systems Design	5	112
Kansas	do	5	100
Georgia Tech	do	5	105
Stanford	do	5	120
Purdue	do	5	112
Syracuse	Administration and Management	5	112
South California	do	5	112
Pittsburgh	do	5	112
50 universities ¹	Space Related	150	3,000
Total		204	4,185

¹ Proposals for these 150 students were solicited by NASA in June 1969. 130 university proposals are on hand for evaluation.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
SUSTAINING UNIVERSITY PROGRAM

[Research grants which will not receive new NASA money beyond July 1, 1970]

University/program, principal investigator	Annual level of effort	Termination date
Arizona/03-002-091 Multidisciplinary Research in Space Science and Technology, A. B. Weaver.	\$67,000	May 1970.
Brown/40-002-009 Multidisciplinary Space-Related Research, B. J. Giletti.	33,000	November 1970.
California (L. A.)/05-007-003 Interdisciplinary Space-Oriented Research in the Physical, Biological, and Engineering Sciences, W. F. Libby.	300,000	April 1973.
California Tech./05-002-007 Research in Physics and Astronomy, R. B. Leighton.	200,000	April 1971.
Colorado State/06-002-038 Biology and Engineering of Space and Planetary Life Systems, B. W. Marschner.	35,000	September 1970.
Denver/06-004-078 The Exploitation of Unused NASA Patents, A. A. Ezra.	100,000	June 1972.
Denver/06-004-096 Extending the Universities' Role in the Exploitation of Aerospace Technology, J. Blackledge.	100,000	September 1972.
Drexel/39-004-007 Multidisciplinary Research in Composite Materials and Plasma Engineering, G. E. Dieter.	100,000	June 1972.
Drexel Research and Graduate Education in the Application of Technology to Social Problem Solution.	117,000	February 1973.
Duke/34-001-005 Multidisciplinary Research in the Application of Aerospace Technology to High-Speed Ground Transportation, J. B. Chaddock.	100,000	February 1972.
Florida/10-005-005 Research in Space-Related Sciences, L. E. Grinter.	75,000	November 1970.
George Washington/09-010-030 Multidisciplinary Program of Policy Studies in Science, Technology, and Public Administration, L. H. Mayo.	400,000	September 1972.
Georgia Tech/11-002-018 Multidisciplinary Research in Space Sciences and Technology, V. Crawford.	150,000	March 1971.
Louisville/18-002-005 Basic Research in Physical, Engineering, and Life Sciences, J. A. Dillon, Jr.	44,000	Do.
Maine/20-006-001 Interdisciplinary Studies in Space-Related Science and Technology, S. L. Freeman.	30,000	February 1971.
Maryland/21-002-008 Multidisciplinary Research on the Application of High-Speed Computers to Space-Related Research Problems, W. C. Rheinboldt.	230,000	March 1973.
Miami/10-007-010 Multidisciplinary Research in Space Sciences, E. H. Man.	150,000	November 1972.
Minnesota/24-005-063 Multidisciplinary Research in Space Science and Technology, L. Cahill.	135,000	June 1970.
Missouri/26-004-003 Multidisciplinary Space-Related Research, R. Shiffman.	65,000	February 1971.
Montana State/27-001-001 Research in Space Science and Engineering, I. E. Dayton.	67,000	July 1971.
New Mexico State/32-003-027 Multidisciplinary Research in Space Science and Engineering, J. Monagle.	30,000	September 1970.
University of New Mexico Program for Advanced Study in Public Science Policy and Administration, A. H. Rosenthal.	150,000	February 1972.
New York/33-016-067 Space-Related Research in Areas of Fluid and Solid Mechanics, J. R. Ragazini.	65,000	September 1970.
North Carolina/34-003-040 Sciences in Interaction: A Research Program in Life, Physical and Social Sciences, R. G. Faust.	250,000	Do.
Oklahoma State/37-002-011 Multidisciplinary Research, V. S. Haneman, Jr.	25,000	October 1970.
Oklahoma/37-003-026 Multidisciplinary Research in Space Science and Engineering, C. D. Riggs.	67,000	January 1971.
Pennsylvania/39-010-001 Research in the Conversion of Various Forms of Energy by Unconventional Techniques, M. Altman.	83,000	July 1970.
Penn State/39-009-015 Multidisciplinary Space-Related Research, P. Ebaugh.	200,000	September 1972.
Pittsburgh/39-011-002 Multidisciplinary Research on the Management of Systems, H. E. Hoelscher.	130,000	August 1972.
Pittsburgh Studies in the Management and Administration of R. & D. Programs, T. Davy.	50,000	November 1972.
Purdue/15-005-021 Multidisciplinary Research in Space Science and Engineering, F. N. Andrews.	133,000	January 1971.
Southern California/05-018-044 Multidisciplinary Research, W. C. Biel.	200,000	July 1972.
Southern California Multidisciplinary Research in the Management of Large-Scale Public Programs, D. Mars.	67,000	June 1971.
Southern Methodist/44-007-006 Multidisciplinary Research, H. A. Blum.	100,000	February 1972.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUSTAINING UNIVERSITY PROGRAM—Continued

[Research grants which will not receive new NASA money beyond July 1, 1970]

University/program, principal investigator	Annual level of effort	Termination date
Syracuse Multidisciplinary Studies in Organization and Public Policy, J. C. Honey.	200,000	January 1973.
Vermont/46-001-008 Research with Particular Emphasis on Materials Sciences, D. Johnstone.	100,000	February 1972.
VPI/47-004-006 Multidisciplinary Research, F. W. Bull and J. A. Jacobs.	45,000	September 1970.
Washington (St. Louis)/26-008-006 Multidisciplinary Research in Space Sciences, G. E. Pake.	130,000	March 1971.
Washington (St. Louis)/26-008-054 Application of Satellite Communications to Educational Development, R. Morgan.	100,000	September 1972.
West Virginia/49-001-001 Space-Related Scientific and Engineering Basic Research, N. F. Wilson.	100,000	October 1972.
Alabama A. & M. Development of a Computer Code, M. C. George.	22,716	June 1970.
Bishop College Synthesis of 1,2-Dimethylcyclobutadiene, K. A. Huggins.	12,170	August 1970.
Bishop College Radiolytic Grafting of Monomers to Polymeric Films, J. E. Wilson.	8,989	Do.
Bowie State Cosmic Ray Physics, Hugh Tornabene.	24,684	Do.
Delaware State Specific Heat of Platinum, Jason Gilchrist.	9,061	July 1970.
Federal City College Detectors for Extremely Relativistic Particles, Homer C. Wilkins.	29,434	Do.
Federal City College Phenomena Related to Spacecraft Electrochemical Devices, Maxine L. Savitz.	25,000	Do.
Howard Low-energy Activation Analysis, G. A. Ferguson.	6,000	Do.
Morgan State Programed Course in Astronomy, R. B. Collagan.	16,165	Do.
Morgan State Photochromism, Ernest F. Silversmith.	6,407	Do.
Oakwood College Synthesis of Ninhydrin Analogs, E. A. Cooper.	24,829	Do.
Prairie View A. & M. Safety Analysis of Structures, J. Kasiraj.	15,000	August 1970.
Prairie View A. & M. Isolating Antimicrobial Agent from Acorns, Thomas P. Dooley.	14,552	Do.
Prairie View A. & M. Radiation on the Plasma Deoxyribonuclease I, V. M. Doctor.	5,700	Do.
Prairie View A. & M. Rapid Method of Determining Chloride in Rain Water; Solubility of Nickel Phosphate, C. T. Stubblefield.	5,700	Do.
Prairie View A. & M. Analysis of Solid or Liquid Solutions by X-Ray Fluorescence, Ivory V. Nelson.	10,066	Do.
Talladega Insulators and Semi-Conductors, Aleyamma George.	18,658	June 1970.
Texas Southern Interaction of Solar Radiation and Matter, Charvus M. Womak.	6,000	August 1970.
Texas Southern Determination of Molybdenum in Titanium Alloys, F. Wilson.	10,000	Do.
Tuskegee Develop Software Amtran 1620 Computer, R. A. Erdey.	24,501	June 1970.
Tuskegee Growing of Insulating Magnetic Crystals, Fred M. Reames.	23,750	Do.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., March 13, 1970.

Mr. JOSEPH ONEK,
Committee on Labor and Public Welfare,
U.S. Senate, Washington, D.C.

DEAR MR. ONEK: In accordance with your telephone request of March 13, 1970, I am forwarding herewith three tables showing our research and development operating costs for universities and colleges. Table I is an overall summary of these costs. Table II lists the costs for universities proper by state and by university and college. Table III shows the costs for Federally Funded Research and Development Centers (FFRDC's) administered by universities and colleges arranged by state.

If there is any additional information which you may need, please let me know.

Sincerely,

S. G. ENGLISH,
Assistant General Manager
for Research and Development.

U.S. ATOMIC ENERGY COMMISSION

TABLE I.—SUMMARY OF RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, FISCAL YEARS 1968-71

	Fiscal year—			
	1968	1969	1970	1971
Total universities and colleges, excluding federally funded research and development centers (FFRDC's).....	\$99,893	\$101,368	\$100,260	\$96,629
FFRDC's ¹	81,828	84,106	82,952	78,747
Total.....	181,721	185,474	183,212	175,376

¹ Excludes costs for the following FFRDC's administered by universities and colleges: Argonne National Laboratory (Argonne University Associates and University of Chicago); Brookhaven National Laboratory (Associated Universities, Inc.); Lawrence Radiation Laboratory at Livermore (University of California); Los Alamos Scientific Laboratory (University of California); Oak Ridge Associated Universities; and National Accelerator Laboratory (Universities Research Association).

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71

University or college	Fiscal Year—			
	1968	1969	1970	1971
Alabama:				
Auburn University.....	0	32	26	26
Tuskegee Institute.....	64	33	36	0
Total, Alabama.....	64	65	62	26
Alaska: Alaska, University of.....	214	271	271	271
Arizona:				
Arizona State University.....	77	89	87	90
Arizona, University of.....	424	453	439	376
Total, Arizona.....	510	542	526	466
Arkansas: Arkansas, University of.....	107	167	163	160
California:				
California Institute of Technology.....	2,669	2,593	2,472	2,403
San Diego State College.....	64	59	61	34
Loma Linda University.....	82	65	29	0
Stanford University.....	570	608	568	662
California, University of, Berkeley.....	747	495	547	546
California, University of, Davis.....	2,289	2,058	2,187	1,983
California, University of, Irvine.....	529	794	877	775
California, University of, Los Angeles.....	4,178	4,550	4,341	4,416
California, University of, Riverside.....	370	360	335	365
California, University of, San Diego.....	2,413	2,313	2,106	2,075
California, University of, San Francisco.....	565	605	660	661
California, University of, Santa Barbara.....	215	210	210	230
California, University of, Santa Cruz.....	0	0	30	28
Southern California, University of.....	517	676	360	386
Total, California.....	15,208	15,386	14,783	14,564
Colorado:				
Colorado School of Mines.....	52	0	0	0
Colorado State University.....	357	291	313	237
Colorado, University of, Denver Medical Center.....	14	14	15	14
Colorado, University of.....	933	888	883	904
Total, Colorado.....	1,356	1,193	1,211	1,155
Connecticut:				
New England Institute for Medical Research.....	71	53	48	50
Connecticut, University of, Storrs.....	72	58	55	58
Connecticut, University of, Hartford.....	0	36	36	35
Yale University.....	3,358	3,432	3,316	2,847
Total, Connecticut.....	3,501	3,579	3,455	2,990
Delaware: Delaware, University of.....	21	65	30	35

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71—Continued

[In thousands of dollars]

University or college	Fiscal Year—			
	1968	1969	1970	1971
District of Columbia:				
American University.....	21	22	15	14
Catholic University of America.....	52	103	82	82
George Washington University.....	20	22	21	20
Georgetown University.....	121	49	50	43
Howard University.....	12	12	12	12
Total, District of Columbia.....	226	208	180	171
Florida:				
Florida State University.....	1,196	1,036	1,037	1,107
Nova University.....	0	40	41	40
Florida, University of.....	405	268	367	384
Miami, University of.....	319	413	388	401
Total, Florida.....	1,920	1,757	1,833	1,932
Georgia:				
Emory University.....	69	75	77	79
Georgia Institute of Technology.....	309	359	276	283
Georgia, Medical College of.....	0	25	25	24
Georgia, University of.....	378	485	597	581
Total, Georgia.....	756	944	975	967
Hawaii: Hawaii, University of.....	593	517	519	470
Idaho: Idaho State University.....	10	10	0	0
Illinois:				
Illinois Institute of Technology.....	153	151	149	155
Illinois State University.....	18	13	0	14
Loyola University, Illinois.....	0	40	40	40
Northwestern University.....	292	245	182	169
St. Procopius College.....	83	86	81	83
Chicago, University of.....	4,596	4,533	4,816	4,534
Illinois, University of, Urbana.....	4,192	4,065	4,010	3,733
Illinois, University of, Chicago Circle.....	38	55	29	29
Total, Illinois.....	9,372	9,188	9,307	8,757
Indiana:				
Indiana University, Bloomington.....	149	210	192	177
Indiana University, Indianapolis.....	45	41	28	28
Purdue University.....	1,286	1,545	1,652	1,663
Notre Dame, University of.....	1,333	1,363	1,420	1,397
Total, Indiana.....	2,813	3,159	3,292	3,265
Iowa:				
Dordt College.....	10	8	0	0
Iowa State University.....	198	142	33	68
Iowa, University of.....	64	94	98	111
Total, Iowa.....	272	244	131	179
Kansas:				
Kansas State University.....	91	219	311	305
Kansas, University of.....	440	390	400	404
Wichita State University.....	23	23	23	23
Total, Kansas.....	554	632	734	732
Kentucky:				
Morehead State University.....	8	6	6	7
Murray State University.....	25	23	0	0
Kentucky, University of.....	193	164	82	65
Louisville, University of.....	34	20	0	0
Total, Kentucky.....	260	213	88	72
Louisiana:				
Louisiana State University, Baton Rouge.....	118	212	281	278
Louisiana State University, New Orleans.....	11	0	0	0
Tulane University.....	45	108	88	103
Total, Louisiana.....	174	320	369	381

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71—Continued

[In thousands of dollars]

University or college	Fiscal Year—			
	1968	1969	1970	1971
Maryland:				
Johns Hopkins University.....	1,062	959	988	1,032
Maryland, University of.....	1,771	2,003	2,132	2,001
Total, Maryland.....	2,833	2,962	3,120	3,033
Massachusetts:				
Boston College.....	80	61	61	63
Boston University.....	28	34	31	33
Brandeis University.....	334	357	282	295
Clark University.....	19	25	25	30
Harvard University.....	1,828	1,808	1,808	1,752
Massachusetts Institute of Technology.....	7,087	6,886	6,968	6,401
Northeastern University.....	33	64	66	66
Southeast Massachusetts Technological Institute.....	0	100	0	80
Smith College.....	0	0	27	0
Tufts University.....	514	450	405	400
Massachusetts, University of.....	176	224	231	231
Wellesley College.....	17	17	17	17
Worcester Polytechnic Institute.....	20	25	25	25
Total, Massachusetts.....	10,136	10,051	9,946	9,393
Michigan:				
Michigan State University.....	1,921	2,019	1,947	1,864
Michigan Technological University.....	93	44	96	91
Oakland University.....	31	54	55	55
Michigan, University of.....	2,361	2,765	2,628	2,413
Wayne State University.....	151	139	113	109
Western Michigan University.....	15	15	16	16
Total, Michigan.....	4,572	5,036	4,855	4,548
Minnesota:				
St. Mary's College.....	14	0	0	0
St. Olaf College.....	5	0	0	0
Minnesota, University of.....	1,916	1,666	1,637	1,663
Total, Minnesota.....	1,935	1,666	1,637	1,663
Mississippi: Mississippi, University of.....	50	19	14	14
Missouri:				
Missouri, University of, Columbia.....	65	57	59	46
Missouri, University of, Rolla.....	106	111	12	12
Washington University, St. Louis.....	289	387	378	368
Total, Missouri.....	460	555	449	426
Montana:				
Montana State University.....	36	65	0	28
Montana, University of.....	20	13	0	13
Total, Montana.....	56	78	0	41
Nebraska: Nebraska, University of.....	112	83	50	50
Nevada:				
Nevada, University of, Reno.....	48	204	204	195
Nevada, University of, Las Vegas.....	143	34	120	130
Total, Nevada.....	191	238	324	325
New Hampshire:				
Dartmouth College.....	33	28	36	39
New Hampshire, University of.....	10	24	12	15
Total, New Hampshire.....	43	52	48	54
New Jersey:				
Institute for Advanced Study.....	61	61	62	62
New Jersey College of Medicine and Dentistry.....	32	20	15	0
Princeton University.....	2,356	2,727	2,730	2,528
Rutgers University.....	139	91	107	114
Stevens Institute of Technology.....	216	230	212	212
Total, New Jersey.....	2,804	3,129	3,126	2,916

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71—Continued

[In thousands of dollars]

University or college	Fiscal Year—			
	1968	1969	1970	1971
New Mexico:				
New Mexico Highlands University	10	10	11	10
New Mexico, University of	61	29	0	0
Total, New Mexico	71	39	11	10
New York:				
Adelphi University	19	17	0	0
City University of New York	101	81	104	96
Brooklyn College, City University of New York	34	25	26	26
Hunter College, City University of New York	20	32	18	18
Queens College, City University of New York	66	27	30	30
Clarkson College of Technology	71	119	130	120
Columbia University, College of Pharmaceutical Sciences	16	16	0	0
Columbia University	4,773	4,617	4,521	4,379
Cornell University	1,446	1,698	1,730	1,635
Fordham University	47	25	25	25
Long Island University	22	0	10	10
Mount Sinai School of Medicine	0	35	35	33
New York Medical College	18	12	0	0
New York University	1,777	1,743	1,731	1,706
New York University, University Heights Center	28	0	0	0
Brooklyn, Polytechnic Institute of	22	71	52	65
Rensselaer Polytechnic Institute	1,062	962	1,006	1,014
Rockefeller University	68	68	94	95
New York, State University of, Albany	0	49	51	49
New York, State University of, Buffalo	145	255	184	180
New York, State University of, Stony Brook	347	669	796	759
New York, State University of, Medical Center	57	42	44	54
New York, State University of, Plattsburgh	0	12	0	0
Syracuse University	300	226	213	225
Albany Medical College	23	22	11	0
Rochester, University of	4,517	4,579	4,365	4,293
Yeshiva University	153	135	140	134
Total, New York	15,132	15,537	15,316	14,946
North Carolina:				
North Carolina, Agricultural & Technological State University	17	0	15	15
Duke University	891	861	878	888
North Carolina State University	328	461	310	416
North Carolina University, Chapel Hill	333	499	502	452
Wake Forest University	38	39	40	38
Total, North Carolina	1,607	1,860	1,745	1,809
North Dakota: North Dakota, University of	54	45	46	48
Ohio:				
Bowling Green State University	1	0	0	0
Case Western Reserve	1,320	1,146	1,103	1,030
Kent State University	0	0	40	40
Ohio State University	560	699	752	807
Ohio University	8	8	18	17
Cincinnati, University of	40	36	122	181
Dayton, University of	0	15	9	0
Toledo, University of	112	151	49	48
Total, Ohio	2,041	2,055	2,093	2,123
Oklahoma:				
Oklahoma State University	22	0	42	76
Oklahoma, University of	79	96	91	81
Total, Oklahoma	101	96	133	157
Oregon:				
Oregon State University	592	532	495	438
Reed College	5	0	0	0
Oregon, University of	409	495	476	494
Total, Oregon	1,006	1,027	971	932

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71—Continued

University or college	Fiscal Year—			
	1968	1969	1970	1971
Pennsylvania:				
Carnegie Mellon University	2,061	1,904	1,600	1,524
Drexel Institute of Technology	0	43	30	0
Duquesne University	18	16	0	0
Jefferson Medical College	59	40	59	56
Lehigh University	58	113	99	91
Pennsylvania State University	525	516	527	435
Temple University	138	133	125	90
Pennsylvania, University of	1,971	1,823	1,813	1,738
Pittsburgh, University of	460	513	524	534
Total, Pennsylvania	5,290	5,101	4,777	4,468
Rhode Island:				
Brown University	768	591	630	605
Rhode Island, University of	45	0	0	0
Total, Rhode Island	813	591	630	605
South Carolina:				
Clemson University	38	44	41	45
South Carolina, University of	112	83	90	90
Total, South Carolina	150	127	131	135
South Dakota:				
South Dakota State University	11	11	7	0
South Dakota, University of	50	35	42	40
Total, South Dakota	61	46	49	40
Tennessee:				
Tennessee, University of, Knoxville	1,324	1,410	1,515	1,271
Tennessee, University of, Memphis	107	82	65	65
Vanderbilt University	170	154	108	110
Total, Tennessee	1,601	1,646	1,688	1,446
Texas:				
Baylor University	0	25	26	26
North Texas State University	18	0	0	0
Rice University	866	842	925	840
Southwest Texas State College	0	25	25	24
Texas A. & M. University	740	896	930	823
Texas Christian University	20	0	0	0
Texas Technological College	12	16	49	39
Houston, University of	101	144	172	169
Texas University, MD Anderson Hospital	68	45	45	43
Texas, University of, Austin	683	671	787	873
Texas, University of, Dallas	0	29	84	105
Total, Texas	2,508	2,693	3,043	2,942
Utah:				
Brigham Young University	109	42	44	45
Utah, University of	1,004	999	942	940
Utah State University	87	53	71	73
Total, Utah	1,200	1,094	1,057	1,058
Vermont: Vermont, University of	46	75	47	49
Virginia:				
Virginia, Medical College of	82	70	54	55
Old Dominion College	19	18	18	21
Roanoke College	4	16	17	17
Virginia, University of	366	196	246	248
Virginia Polytechnic Institute	92	56	65	66
Total, Virginia	563	356	400	407

U.S. ATOMIC ENERGY COMMISSION

TABLE II.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR UNIVERSITIES AND COLLEGES, EXCLUDING FFRDC'S, FISCAL YEARS 1968-71—Continued

[In thousands of dollars]

University or college	Fiscal Year—			
	1968	1969	1970	1971
Washington:				
Washington, University of	2,181	2,232	2,269	2,223
Washington State University	266	224	234	241
Western Washington State College	10	10	10	12
Total, Washington	2,457	2,466	2,513	2,476
West Virginia: West Virginia University	44	0	0	0
Wisconsin:				
Marquette University	77	43	51	54
Wisconsin, University of, Madison	3,007	3,178	3,036	2,995
Wisconsin, University of, Milwaukee	13	13	8	0
Total, Wisconsin	3,097	3,234	3,095	3,049
Wyoming: Wyoming, University of	55	72	82	80
Puerto Rico: Puerto Rico, University of	882	879	935	793
Total	99,893	101,368	100,260	96,629

U.S. ATOMIC ENERGY COMMISSION

TABLE III.—RESEARCH AND DEVELOPMENT OPERATING COSTS FOR FEDERALLY FUNDED RESEARCH AND DEVELOPMENT CENTERS (FFRDC'S) ADMINISTERED BY UNIVERSITIES AND COLLEGE,¹ FISCAL YEARS 1968-71

[In thousands]

Federally funded research and development centers	Fiscal year—			
	1968	1969	1970	1971
California:				
Lawrence Radiation Laboratory—Berkeley (University of California) ..	\$37,025	\$37,025	\$36,613	\$35,345
Stanford Linear Accelerator Center (SLAC), (Stanford University)	21,220	23,493	23,900	24,500
Total, California	58,245	60,518	60,513	59,845
Iowa: Ames Laboratory (Iowa State University)	8,049	7,654	7,451	6,802
Massachusetts: Cambridge Electron Accelerator (CEA), (Harvard University) ..	3,505	3,555	3,500	2,400
New Jersey:				
Princeton Stellerator (Princeton University)	6,879	7,405	7,458	7,700
Princeton-Pennsylvania Accelerator (PPA), (Princeton University)	5,150	4,974	4,030	2,000
Total, New Jersey	12,019	12,379	11,488	9,700
Total, FFRDC's	81,828	84,106	82,952	78,747

¹ Excludes costs for the following FFRDC's administered by universities and colleges: Argonne National Laboratory (Argonne University Associates and University of Chicago); Brookhaven National Laboratory (Associated Universities, Inc.); Lawrence Radiation Laboratory at Livermore (University of California); Los Alamos Scientific Laboratory (University of California); Oak Ridge Associated Universities; and National Accelerator Laboratory (Universities Research Association).

APPENDIX III.—EXCHANGE BETWEEN SENATOR MIKE MANSFIELD AND
NSF DIRECTOR McELROY ON IMPACT OF SECTION 203

U.S. SENATE,
Washington, D. C., December 5, 1969.

Dr. WILLIAM D. McELROY,
*Director, National Science Foundation,
Washington, D. C.*

DEAR DR. McELROY: On November 19, 1969, the Military Procurement Authorization for 1970 was signed into law by the President. Section 203 of that law expresses a fundamental change in Federal funding for research. In essence, it emphasizes the responsibility of the civilian agencies for the long-term, basic research. It limits the research sponsored by the Defense Department to studies and projects that directly and apparently relate to defense needs. The Secretary of Defense already has directed a determination of what projects do not comply with Section 203 and has begun an internal review of current projects. He has also invited the National Academy of Sciences to make an independent determination of those projects that may fall into a grey area with respect to Section 203. There is no design in the passage of this section of the law to eliminate or reduce the Federal Government's contribution to research. It is designed to realign and restrict the sponsorship of research to defense missions.

It is anticipated that a number of research projects and studies will not comply with Section 203. Some of these will be of a quality and importance that would justify sponsorship by civilian agencies. This is important, for the intent of Section 203 is to obtain a new balance among civilian agencies in their responsibilities for funding research, not simply to cut off DoD support of the research that does not meet the requirements of Section 203. The legislative record of Section 203 makes it clear that Congress seeks an orderly transfer of high quality research projects that the Defense Department can no longer fund to other departments and agencies. Obviously a change of this kind will pose some difficulties which will require thoughtful, positive action within the agencies and in Congress to resolve.

I am writing to solicit your cooperation with the Department of Defense and the Bureau of the Budget as they adjust to the mandate of Section 203. And I would appreciate your timely advice and recommendations in its implementation.

Again, it is the Congressional intent to continue high quality research projects even if the sponsorship changes to another Federal agency. Some financial and funding arrangements will probably have to be made, and here I am looking to the Bureau of the Budget to recommend appropriate action.

Sincerely yours,

MIKE MANSFIELD.

NATIONAL SCIENCE FOUNDATION,
Washington, D. C., December 11, 1969.

Hon. MIKE MANSFIELD,
*U.S. Senate,
Washington, D. C.*

DEAR SENATOR MANSFIELD: Thank you for your letter of December 5, 1969 concerning the intent of Section 203 of the Military Procurement Authorization Act for 1970 not to eliminate or reduce the Federal Government's contribution to research.

I have been following the Congressional deliberations on Section 203 and particularly the views and comments which you have from time to time expressed. It is gratifying to me to have further confirmation of your views in the letter of December 5.

I am also aware that you have written the Budget Director, and I know that he is giving careful consideration to your views in developing his budgetary recommendations to the President.

As you can well understand, the question of realigning federal sponsorship of research is a matter of concern to all federal agencies which support research. From the standpoint of the Foundation's overview of the general science picture in this country, I have taken care to point out to the Budget Director and other officials the implications of reductions in defense support of research, particularly, in universities and other non-profit organizations. In particular, I have emphasized that whatever decisions are reached concerning realignments of research sponsorship, careful provision must be made to insure the continued support of high quality research. This recognizes that any significant reduction in defense grants and contracts will, of course, require researchers to seek other sources of support. The Foundation would in many cases, therefore, be in receipt of proposals from investigators heretofore under defense sponsorship.

I can assure you that within whatever funds are made available to the Foundation our policy will continue to be to consider the merits of all research proposals submitted to the Foundation.

Sincerely yours,

W. D. McELROY,
Director.

APPENDIX IV.—RELEASE OF HOUSE COMMITTEE ON SCIENCE AND ASTRONAUTICS ON 1971 NSF AUTHORIZATION

[Press release from Committee on Science and Astronautics, House of Representatives, Washington, D.C. March 24, 1970]

The House Committee on Science and Astronautics today acted on the Fiscal 1971 National Science Foundation Authorization Bill, Chairman George P. Miller (D-Calif.) announced. \$500 million for NSF programs authorized by the Committee had been requested by the Administration. The bill ordered to be reported to the full House totals \$527.6 million, an increase of \$27.6 million over the President's budget.

In contrast to this action, the same committee applied cuts of over \$9 million to the NSF budget submitted by the Nixon Administration last year. The increases approved today were recommended by the Subcommittee on Science, Research and Development, chaired by Representative Emilio Q. Daddario (D-Conn.). The Subcommittee held seven open hearings and three executive sessions before arriving at the revised budget totals.

Commenting on the about-face taken by the Committee, Mr. Daddario stated: "This year the situation with regard to the National Science Foundation has radically changed. During the past year, we have found that demands for new programs were coupled with cutbacks in scientific research and training by the mission agencies. But resources have not been made available to the NSF to fund the meritorious programs among those being terminated. Our review has shown the Administration request is inadequate to meet the bare minimum requirements or the NSF support of American science during Fiscal 1971."

There were five specific changes adopted by the Committee. Graduate traineeships, which are awarded to over 200 universities which in turn select the recipients, were increased, \$9.5 million. The Administration planned to eliminate all new starts, but the Committee action restores the program to the level of Fiscal 1970. This restoration makes no allowance for similar cutbacks by six other Federal agencies, and only slows down the rate at which such support is shrinking.

\$10 million was added to support academic science projects being terminated by the various mission agencies of the government, such as the Defense Department and NASA. The Committee estimates the total of such projects at about \$60 million, most of them being of high quality. This additional competition for funds is having especially adverse effects on younger scientists and those scientists in smaller universities. These funds will permit the NSF to fund approximately one-fifth of those projects being dropped by the other agencies.

The College Science Improvement Program received an increase of \$4.0 million, to a total of \$8.0 million. This program for improving undergraduate instruction in the sciences had received proposals totaling \$24 million in Fiscal 1969 alone. It has been very successful in upgrading instruction in the sciences in undergraduate colleges, who train a disproportionately large share of undergraduate students who attain advanced degrees.

The Committee added \$4.0 million for Environmental Research in Federal laboratories. Congressman Daddario addressed the importance of this by stating:

"Many environmental problems require research and pilot plant capabilities beyond the resources of individual universities. A recognition of this need for environmental laboratories of significant size has been reflected in legislation introduced in both Houses of Congress. The problems, however, are of such magnitude and importance that delay seems unwise."

An increase of \$130,000 was voted for the State and local Inter-governmental Science Policy Planning Program. This supports projects designed to assist state and local governments in planning for better utilization of science and technology, and in attacking environmental problems at the state, local and regional levels.

APPENDIX V.—EXCHANGE BETWEEN SENATOR JENNINGS RANDOLPH
AND SENATOR EDWARD M. KENNEDY

U.S. SENATE,
Washington, D.C., April 15, 1970.

Hon. EDWARD M. KENNEDY,
U.S. Senate, Washington, D.C.

DEAR TED: The Subcommittee on Science and Technology, which I chair, has just completed a first round of hearings on the technology transfer programs of the Federal Government.

You may be aware that, instead of evolving toward a comprehensive system, the existing Federal programs appear to be contracting. This is occurring at the very time when the transfer of new technology is of critical importance to the survival of substantial segments of the small business community.

For example, the expiration of the State Technical Services Program, to which you referred in your introductory remarks on S. 3700, and the downgrading of the technology utilization division of the Small Business Administration have left almost a complete void at the level of face-to-face contact with businessmen to determine their problems which may be susceptible to technical solutions. There is persuasive evidence that such personal contact offers the best means of disseminating the bulk of research and development which has been performed at the taxpayers' expense.

As you know, my Subcommittee counsel discussed this matter with your staff several weeks ago.

I wished to bring this matter to your attention because of the possibility that, in your capacity as Chairman of the Subcommittee on the National Science Foundation, you might be able to further explore whether the varied activities of the Foundation could serve as a means of both examining and designing a mechanism to fill this vacuum.

It is recognized such program design by the Foundation would not be a substitute for the operating State delivery programs. However, such an effort could serve two useful purposes: (1) by affording an element of continuity to existing State and local programs, so that their \$40 million in start-costs will not be dissipated; and (2) by advancing consideration of the format for a permanent and adequate system by which the States can assist in distributing technology developed on the Federal level.

If you feel that this approach has merit, I would be pleased to support appropriate initiatives by your Subcommittee and the Foundation in this area.

With sincere appreciation for your consideration and with best wishes, I am
Truly,

JENNINGS RANDOLPH,
Chairman, Subcommittee on Science and Technology.

U.S. SENATE,
Washington, D.C., April 27, 1970.

Hon. Jennings Randolph,
*U.S. Senate
Washington, D.C.*

DEAR JENNINGS: Thank you for writing me about the expiration of the State Technical Services Program.

At the National Science Foundation hearings on April 16th, I asked Foundation officials whether they could design a mechanism to fill this vacuum. Dr. McElroy seemed quite willing to have the NSF undertake this responsibility if funds could be made available. I intend, therefore, to recommend that the Congress provide the necessary funds.

Again, thank you and your Subcommittee counsel for bringing this important matter to my attention.

Sincerely,

EDWARD M. KENNEDY.

Appendix VI

PREPARED STATEMENT OF DR. THOMAS G. FOX, SCIENCE ADVISER TO THE GOVERNOR OF PENNSYLVANIA

PREMISE*

The transition: National science to domestic technology.—We are in a period of national transition from a need of the past thirty years for new programs in national science (defense, space, atomic energy) to an urgent need to mount new programs generating domestic technology meeting the pressing public needs of housing, health, transportation, environment, and education.

The innovative development of domestic technology (in housing, health, transportation, environment, and education) insuring the quality of life throughout the U.S. is the major goal of the Seventies.

PRACTICAL PAYOFF AND THE STATE SCIENCE ROLE

It is apparent that needs in housing, health, transportation, environment, and education are traditionally and properly the responsibility of state and local governments.

It is absolutely necessary that state leadership in development, adaptation, and use of domestic technology according to local needs and desires be mounted speedily.

Federal leadership to stimulate and to coordinate national attacks on domestic problems is mandatory.

Thus, Federal and State programs must operate in concert to contribute more than the sum of uncoordinated efforts.

Some states (Connecticut, New York, North Carolina, Pennsylvania, Georgia) have in recent years supported interdisciplinary applied research centers in their universities. They have found effective ways to provide continuing responsible communication and mutual response between the academics in such centers and the practical leaders in the appropriate state, local and federal agencies, and the related industry.

INTERDISCIPLINARY APPLIED SCIENCE PROGRAMS

Dr. DuBridges, the President's Science Adviser, has called for the establishment of interdisciplinary centers of applied science working innovatively on these problems.

The NSF is beginning a new program of this type in the universities.

PROPOSED POLICY

We believe

The Nation's science and universities will serve us better in the 70s if:

There are NSF and state monies supporting in concert applied research on innovative developments of the required domestic technology.

States are given a leading role in seeing that the centers are responsive and contributing to practical needs of the region.

NSF (and other agency) funding of applied programs encourage, assist, and accept state leadership in state and region-oriented programs throughout the U.S.

We believe that congressional leaders and committees can greatly accelerate the certain and effective use of our scientific knowledge and universities to serve urgent human needs by adopting this policy.

Program proposal

We propose an NSF budget for pioneering applied research on new domestic technology of:

\$30 million in Fiscal Year 1971.

\$45 million in Fiscal Year 1972.

\$60 million in Fiscal Year 1973.

*See Appendix for a further perspective on this premise.

Remark

\$30 million is just times the annual budget proposed in Pennsylvania for this purpose.

\$60 million is 12% of the current NSF budget, and may well be closer to 5% of the NSF budgets later in the 70s.

5% to 10% of NSF funding to promote use of our science to serve domestic human needs throughout the regions of the Nation does not seem excessive.

NSF should be instructed by Congress

1. To adopt funding procedures and programs which—encourage, promote assist: the development of state and regional science policy groups and programs of state funding throughout the country. Fund jointly programs of applied research initiated by individual states with strong coupling to agencies and industries responsible for practical domestic problems throughout the Nation.

2. To establish an advisory committee, comprised of representatives of industry, state and local governments, and universities knowledgeable and concerned with the development and adaptation of domestic technology, meeting regional needs, to advise on the implementation of policy and programs described above.

3. In implementation, the NSF would need to draw up statements of goals and suggested structures of these state organizations, and criteria for acceptability. NSF should plan in-depth briefing on a continuing basis as needed to advise state representatives as to useful approaches.

Such a program

Will promote in each participating state a conscious and growing dedication and utilization of local leadership and local resources to solve local problems.

State governments will develop the sophistication and means to understand, to develop or adapt, and to use technology. They will learn to cope.

Universities will become more concerned with local domestic needs and will better serve their communities and students. A better interface between universities and the real world of local government and industry will result.

Greater coordination of federal and state policies and programs will be fostered, thereby increasing the efficiency and effectiveness of national programs designed to meet our domestic problems.

APPENDICES

- I. Perspective on the Nation's Scientific and Engineering Programs.
- II. Proposed Criteria for NSF-State Demonstration Programs.
- III. Examples of Successful State Science Programs.
- IV. Domestic Technology for the 70s: An Outline of Premise & Policy.
- V. Roles for Different Institutions.

APPENDIX I

PERSPECTIVE ON THE NATION'S SCIENTIFIC AND ENGINEERING PROGRAMS

Measures of the Nation's scientific and engineering programs include 1) their intellectual quality in advancing knowledge, and 2) the vigor with which they apply this knowledge to meet human needs.

On the application of science, the U.S. experience in this century may, perhaps, be categorized under three main headings:

1st Period—Science for Industry (Chiefly Consumer-oriented)

In the first third of the century we learned to organize research and development undertakings in industry to speed technological progress in selected areas. The universities grew to support this effort through basic research and training of scientists and engineers. The happy result was to escape from the economy of scarcity of all previous eras.

2nd Period—Science for Defense

In the middle third of the century we learned how to mount massive national undertakings to assure technological progress in areas vital to our national defense.

Congress, federal agencies, our university communities, and the new aerospace industry learned to work together to do the job effectively.

3d Period—Science for Society (Chiefly Domestic Technology)

In the last third of this century our Nation is faced with critical domestic economic urban and environmental problems whose solutions involve both technological and social factors. We must learn how to use our knowledge and resources effectively to insure technological and social progress. There needs to be a revival of engineering scholarship in the broadest sense with close participation by federal, state and local governments and industry in new partnerships—working together in ways as yet undefined.

APPENDIX II

PROPOSED CRITERIA FOR THE NSF-STATE DEMONSTRATION PROGRAMS

1. Programs submitted by the state science board or other appropriate state agency are designed to meet the state's environmental and social needs and utilize more effectively the resources of the state.
2. Individual projects are directed at the problems or opportunities within the state, with promise of applicability in other states generally.
3. Individual projects should be preferably inter-disciplinary and inter-institutional.
4. Projects are to be conducted with effective communication among the appropriate government, professional, and industrial agencies and institutions, acting as advisory bodies or as joint client-sponsors or in other arrangements to couple development with potential users.
5. Projects can be funded by grants or contracts with universities or nonprofit institutions, including state or local government agencies, or by contract with industry.
6. In general, the project should better mobilize the state's scientific and technological resources in concentrated effort to innovate, demonstrate, or promote new conceptual and/or technological approaches to local problems or opportunities and to train professionals and students in the disciplines required for their implementation. Ideally, the project provides a focal point for input from all appropriate elements of the community to define the problem and find new solutions.

APPENDIX III

EXAMPLES OF SUCCESSFUL STATE SCIENCE PROGRAMS

"Riverine-estuarine systems" is the scientist's term for lakes and rivers which connect with one another and with the sea. Such waterways link our seacoasts with vast land areas inland and are important fishing grounds, sources of fresh water, recreational areas and natural highways for the transportation of goods and people. Eastern Pennsylvania is served by two such systems, the Delaware and the Susquehanna-Chesapeake. Both link forest and farmland in northern Pennsylvania with the Washington-New York megalopolis which spans the southeastern part of the State. Usage of these waters ranges from fishing and hydroelectric production through irrigation, drinking water and industrial use.

In August of 1966, G-SAC pointed out the vast potential which the Delaware and Susquehanna held for Pennsylvania and decried misuse of these waters, particularly through pollution. G-SAC sponsored a program called Operation Cleanstreams to alert people in business, the Sciences and numerous civic groups to their stake in conserving these waterways. Soon the business community, after evaluating the economic impact of pollution, became active promoters of Cleanstreams. Citizens' groups began to recognize that the Delaware and Susquehanna could provide sorely-needed recreational facilities for southeastern Pennsylvania. And Scientists in both industry and the universities set to work looking for ways to eradicate pollution and develop the Delaware and Susquehanna as transportation and recreation centers.

P-SEF, which had been monitoring all this activity, became convinced that systematic research into the two riverine-estuarine systems held great promise for the economic future of Pennsylvania. The Federal Government, too, was interested in this concept, and accordingly in June, 1968, the National Science Foundation joined with P-SEF in funding any Institute for the Development of Riverine-Estuarine Systems (IDRES).

IDRES is an alliance of universities and research centers which share a strong interest and competency in various facets of riverine-estuarine study. Participating institutions include Lehigh University, the Academy of Natural Science, Temple University, the Franklin Institute, and most recently the Marine Science Consortium, a group of ten Pennsylvania institutions already cooperating in various phases of marine study. Because the lower Delaware and Susquehanna extend into New Jersey and Delaware, there are ex-officio IDRES members from both States.

A unique aspect of IDRES is reflected in the structure and operation of its management. Membership and participation on both the Policy and Advisory Board and the Technical Board consists of representatives of industry and the relevant government agencies, federal, state and regional, sitting with the university and institutional personnel. This special partnership assures constant communication and interaction between the innovators and the ultimate users to promote effective and efficient use of the results.

The money provided by P-SEF and NSF is being used for research apparatus, research by professors and graduate fellows, and information gathering. The guiding concept is a "systems approach" which recognizes the interaction between various uses of the waterways and which minimizes overlapping and duplication between research projects.

A number of IDRES projects have already borne fruit. IDRES researchers have devised a new method of laying undersea pipelines for disposing of concentrated industrial wastes, so that this material can be carried far out to sea rather than being dumped directly into rivers and estuaries. Core-sampling studies of sedimentation in the Delaware have indicated that unsuspected portions of the riverbank are being eroded. And studies of thermal pollution have revealed that temperature changes caused by industrial discharges into the water are changing the life forms in certain parts of the Delaware, which in the long run could result in serious disruption of the "balance of nature" in these waters. Future plans include a study of how greater access and the elimination of floating debris can once more make the lower Delaware and Susquehanna suitable for boating and fishing.

IDRES activities will have repercussions far beyond Pennsylvania's borders. Hailed by the National Science Foundation as a landmark in Federal-State collaboration in applying science and technology through a systems approach to regional problems, IDRES is expected to serve as a prototype for similar programs in entirely different fields.

REGIONAL LABORATORIES AND PROGRAMS

1. The Governor's Council of Science and Technology in 1963-64 identified advanced research laboratories in the forefront of new science and innovative applications of science as having major potential for advancing the economy of the state.

2. The Governor's Science Advisory Committee in 1965 and thereafter identified areas of research and innovation, such as transportation, health care delivery, and environmental control where potential for such centers existed.

3. The Pennsylvania Science and Engineering Foundation in 1968 and 1969 funded eight proposals from such centers totaling \$327,000 or 12% of the two-year budget. These include:

The Regional Development Laboratory in Philadelphia.

The Great Lakes Research Institute in Erie.

The Northeastern Pennsylvania Educational Consortium.

The State Science Planning Center (Penn State; jointly sponsored with NSF).

The Pennsylvania Junior Academy of Sciences.

The NSF New England Conference.

The central concern of each of these centers or programs is to promote the effective utilization of science and engineering to serve the region. In each case, local (regional) support and leadership, involving regional consideration of common goals, resources, and opportunities, is central to the activity.

The RDL in Philadelphia represents an effort to encourage inventions and/or entrepreneurship at various levels, including some successful examples of black entrepreneurs. This center has enjoyed Federal, local, and Commonwealth support in three or four years of its existence.

The Great Lakes Research Institute enjoys financial support and leadership from the industrial and academic communities, and local government. Consideration of regional needs and creation of the Great Lakes Research Institute was the

direct result of an impetus given by the Pennsylvania Science and Engineering Foundation. The interests of the Institute initially center on waste disposal and pollution abatement. Conceivably, GLRI will provide a mechanism for cooperative advanced study involving the colleges and serving the young people, industry, and local government in the area.

The Northeast Pennsylvania Educational Consortium is seeking to mobilize the region toward similar ends.

The purpose of the State Science Planning Center is to develop further insight as to mechanisms whereby states can generate effective programs to utilize innovative science and engineering to meet modern needs.

The NSF New England Conference is a regional conference to explore how states can utilize science and technology to serve society.

APPENDIX IV

DOMESTIC TECHNOLOGY FOR THE 70's: AN OUTLINE OF PREMISE AND POLICY— T. G. FOX 11-30-69

Premise: The Innovative Development of Domestic Technology Insuring The Quality of Life Throughout the US Is The Major Goal of the Seventies.

Innovation: A Dominant Theme.—Characteristic of our age is the rapid generation of new scientific knowledge and the deliberate innovation of new technology vitally affecting our economy and culture. New Knowledge—New Technology—New Service to Humans.

Today many Americans ask whether we are aggressively using science to solve our critical domestic problems and whether the harmful effects of new technology outweigh its benefits.

Innovation For Private Consumption.—New technology for private consumption is developed through R & D efforts of private corporations strongly dependent on universities for basic research and for training scientists and engineers.

National Science.—Development of technology for defense, space, and atomic energy is done through programs mounted by the Federal government in its own laboratories, in universities, and especially in the captive aerospace industry. The programs in leading universities in basic and engineering science are suited to the high science needs of industrial and aerospace programs.

The transition: National science to domestic technology.—We are in a period of national transition from a need for new programs in national science characteristic of the past thirty years to an urgent need to mount new programs generating domestic technology meeting the pressing public needs of housing, health, transportation, environment and education.

Domestic Technology: Special Characteristics.—The choices of technological approaches to environment, education, transportation, housing, and health are distinguishing marks of the local culture and must be made collectively by the people in a given locale or region. In a democracy, such decisions are made by state and local governments, influenced by the informed opinions and desires of diverse local groups, professions, business, and industry.

In a decade, the national housing needs will cost a total of about a trillion dollars, health care nearly as much, and the price tags for transportation and environmental control may exceed many times over the national space budget. We shall meet the as yet incompletely defined goals of the 70's only by marshalling private and industrial as well as government resources at all levels and only by widespread utilization of more efficient innovative technology.

STATE OR REGIONAL

Mobilization of Resources.—Mobilization of human enterprise on the required scale will be effective only if the individuals and institutions involved identify themselves as local constituencies working toward clearly visible local benefits. In most instances the manifold local governments in a given urban area are too fragmental to generate effective regional approaches to domestic technological developments. State governments with broad responsibility for environment, education, highways, health, industrial development, employment, and welfare and providing the environment under which local governments and industry operate in many cases motivate and mobilize the political and technology—generating constituencies in its boundaries. In other instances, a regional organization of a number of states will represent a natural focal point for a sophisticated and coordinated regional approach to developing 'Domestic Technology'.

FEDERAL

Federal agencies, with greater sophistication and experience in leading technological developments and with greater resources than any single state, have great opportunity to initiate, promote, and coordinate innovation of "Domestic Technology". Minimum national standards, for example, in environmental control, are necessary to avoid inequitable regional competition; national programs are required to avoid undue duplication of developmental efforts.

UNIVERSITIES

It is essential that universities generating knowledge and concepts and trained professionals and the great bulk of the domestic industry be involved in the great rebuilding of our urban civilization. Various Federal agencies with close relations with the universities working with the individual states bear a special responsibility: to help the universities achieve at least a partial reorientation of interdisciplinary academic engineering programs directed towards "Domestic Technology".

INDUSTRY

It is equally imperative that the incomparable resources and might of America's private enterprise be dedicated to the high national goals of the seventies. Not only are the needs so great that no other course will suffice; equally important, the stakes are so high that no element of American culture can afford to "cop out" on their ultimate challenge to our systems. State governments, close to the industrial leaders who necessarily have a stake in the community and region in which they are located, have a special responsibility to challenge and mobilize this force locally. Federal agencies, accustomed to work with the captive aerospace R & D industry, have a special responsibility to avoid preferential selection of the latter as most convenient and familiar centers for the new national "Domestic Technology" developments. The facts are, that the resources of the familiar Federal-aerospace companies will fall woefully short for the greatest task of national rebuilding ever attempted.

The "New Federalism" and the Domestic Technology of the 70's Challenges

The key practical questions appear to be:

How do we generate a sophisticated policy on the utilization of science and technology in the individual states or, when appropriate, their regional groupings?

How can we alert our universities and other innovative technology-generating centers to today's problems and utilize present resources in new ways to provide centers of excellence in applied interdisciplinary research on today's domestic problems? How can we insure that this is done in close interface with those ultimately responsible for the choice, adaptation and installation of the end product?

How can we mobilize the private and industrial resources regionally and nationally to meet the challenge of improving and preserving the physical plant and environment of communities throughout America?

How can the federal government stimulate and support the necessary locally oriented political-academic-industrial apparatus in individual states or regional associations?

We believe it the responsibility of the NSF and of the academic scientific and engineering community.

To make it unequivocally clear that the goal of responsible use of knowledge to serve society in at least as challenging and important as that of the generation of knowledge.

To encourage interdisciplinary academic engineering oriented toward real problems in interface with governmental and industrial authorities, preferably local, responsible for practical programs.

To meet its responsibilities to other governmental agencies and to the several states, we believe NSF should:

Promote the formation of high level science policy advisory groups in individual states (or regions).

Through matching funding, join with individual states in establishing interdisciplinary applied research centers of the type envisioned by Dr. duBridge.

"New Federalism" and the Domestic Technology of the 70's Guiding Concepts

Clearly it is not merely desirable but *critical* that the national strategy of the 70's, designed to use the knowledge and resources of our post-industrial age to raise the quality of life for all Americans, be based on a dedicated federal-state alliance. Federal-state policies and programs relevant to the utilization of science in the service of society must strongly reinforce each other, in diverse regions and circumstances.

Patently, this requires close and continuing communication and sensitive coordination, beginning now. A partnership with a responsibility for both the state and Federal government, is surely the essence of "New Federalism".

Obviously, this requires sophistication and insight, at both ends of the exchange. Means must be found to promote sophistication and sensitive understanding where they are in short supply.

Earlier the urgent need in this nation and its universities was greater depth in fundamental research in the basic scientific discipline. This year Dr. duBridges has pointed to the present critical need in centers of interdisciplinary applied science capable of significant contributions to today's urban problems.

Today many well staffed centers of research and development exist and means for production of products appear unlimited. The resources of the innovative genius and industrial insight of this nation must be harnessed in new ways to new ends if the high domestic goals of 70's are to be realized.

What is missing are the concepts, the motivated professionals and the organizational concepts. We need sufficient numbers of our best young (and older) people, prepared with appropriate background, belief in the goals and concepts, and motivated to dedicate themselves to the new task. Our universities traditionally role in our society, and opportunity, is to provide these in sufficient measure. Any strategy must surely be based on university leadership in promoting not less science but more application of science and engineering to today's special problems, not less depth in specialties for some, but more breadth for others. Not less dedication to the discovery of new knowledge, but surely as the university community grows, more dedication of larger numbers to the utilization of knowledge to serve man.

Clearly, applied research concepts directed at the physical structure of our communities and public facilities cannot be generated in isolation from those in authority who are responsible to their communities, nor removed from those with practical knowledge and responsibility for ultimate delivery of technology. Centers of excellence in conceptual pioneering applied research in our universities are essential, but only in strong communication and coupling with those responsible for acceptance, adaptation, and installation of the end product.

In short, industry must respond to the opportunity to provide efficiently the technology to rebuild our cities, to preserve the environment, to provide needed health services, and to make viable the communities in which they are located and limit or elevate the quantity of life characteristic of our technically advanced society.

States must be encouraged to develop strength and sophistication in marshalling their innovative technology-generating resources.

Federal agencies must initiate and coordinate the national effort while encouraging initiative and diversity in the individual states and regions.

Mechanisms for strong interaction of federal-state policies and programs in on-going fashion are essential in disciplinary engineering and applied science on public problems, with a broad base, and a strong interaction with government and industry must be fostered.

APPENDIX V

ROLES FOR DIFFERENT INSTITUTIONS

The functions of the university, government, and industry in finding effective routes to the use of new knowledge to solve our urban and environmental problems and the nature of the partnership among those which may be effective are, perhaps, illustrated by consideration of the several steps involved in new technological developments:

- New Knowledge.
- New Technology and Concepts.
- New Service to Human Needs.

These, and the relative involvements we may expect from elements of society may be visualized as follows:

State of development of new solutions		Relative involvement		
		Client-sponsors		
		University	Com- munity	Industry
Stage 1.....	Definition of problems.....	3	3	1
Stage 2.....	Innovative conceptual solutions.....	3	3	3
Stage 3.....	Explore and develop basic features of solutions.....	3	1	2
Stage 4.....	Feasibility demonstration.....	1	2	2
Stage 5.....	Development.....		3	3
Stage 6.....	Installation.....		3	3
Stage 7.....	Use.....		3	3

The times demand major attention in the immediate future to stages 1, 2, and 3. What are the new innovative engineering-social concepts for marshalling our resources to provide more efficient and effective health care, environmental control, urban regeneration, transportation and the like? We must advance such new concepts, examine them critically and perfect them, and move to demonstration projects quickly. This requires intellectual leadership with university, industry, and governmental leaders and close collaboration among innovator, user, and ultimate supplier.

