DOCUMENT RESUME

ED 268 945 HE 019 313

TITLE	A Renewed Partnership. Report of the White House Science Council Panel on the Health of U.S. Colleges and Universities.
INSTITUTION	Office of Science and Technology Policy, Washington, DC.
PUB DATE	Feb 86
NOTE	57p.
PUB TYPE	Reports - Descriptive (141)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	Change Strategies; Engineering; Federal Aid; Federal Government; Fellowships; Financial Policy; *Government School Relationship; Graduate Study; *Higher Education; Industry; Money Management; Program Administration; Program Costs; *Research; Scholarships; *School Business Relationship; *Sciences; *Technology; Undergraduate Study

ABSTRACT

The interactions between the federal government, colleges, and industry in U.S. research and higher education in the areas of science and engineering were examined by a special panel of the White House Science Council. Recommendations to retain U.S. leadership in areas of science and technology are offered by the panel, which is composed of members of the academic/nonacademic research community. Concerns included: graduate education and research, federal support of university research, restoring the university infrastructure, multidisciplinary science and technology centers, costs of university research, indirect costs, the problem of documenting costs, micromanagement of university research, mandatory cost sharing, indirect cost reimbursement, stability of research support, the peer review process, the structure of grants and contracts, undergraduate scholarships, graduate fellowships, the universities and industry, the universities and the federal laboratories, and the role of state governments. Appended materials include: a list of witnesses appearing before the panel in 1984 and 1985; questions sent to different groups (university presidents, foundations, industrial chief executive officers, principal investigators); correspondents providing input to the panel; and data on indirect costs. (SW)

A RENEWED PARTNERSHIP

An examination of federal government-university-industry interactions in U.S. research and higher education in science and engineering

February 1986

A Report of the
White House Science Council
Panel on the Health of U.S. Colleges and Universities
to the
Office of Science and Technology Policy
Executive Office of the President
Washington, D.C. 20506

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

February 26, 1986

Dear Dr. McTague:

I have the pleasure of transmitting to you the Report of the White House Science Council's Panel on the Health of the U.S. Colleges and Universities, chaired by David Packard with Allan Bromley as Vice Chairman.

The Report, entitled A Renewed Partnership, was discussed in detail with the members of the Science Council and comes to you with their unanimous support.

Both personally and on behalf of the Science Council, I wish to take this occasion to express to the Panel members my appreciation of all the effort that they have devoted to this important study. They have identified the critical issues that must be addressed if we are to retain our national leadership in areas of science and technology that are of central importance to our national future. Their recommendations spell out a national plan of action that merits serious and immediate attention.

Sincerely yours,

Sol Buchsbaum

Solomon Buchsbaum
Chairman
White House Science Council

Dr. John P. McTague
Acting Director
Office of Science and Technology Policy
Executive Office of the President
The White House
Washington, D.C. 20506

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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

February 24, 1986

Dr. Solomon Buchsbaum
Chairman
White House Science Council
Washington, D.C. 20506

Dear Dr. Buchsbaum:

The Panel on the Health of the U.S. Colleges and Universities which you established on May 3, 1982 and which I have had the pleasure of chairing has completed its task, and now transmits to you, herewith, its unanimous Report entitled A Renewed Partnership.

We have benefited greatly from input received from representatives of over one hundred universities and colleges and from over forty private sector organizations. This input has bolstered our belief that we still enjoy, in this country, the benefits of the world's strongest scientific and technological enterprise. But at the same time, it raises disturbing problems and questions concerning both the short- and long-term health of this enterprise.

In our Report, we address these problems and questions and make specific recommendations directed to each of the Federal Government, the universities and the private industries. Although we recognize fully that it will be difficult, particularly under our present national fiscal stringencies, to implement all these recommendations, we are confident that their implementation will ensure the continued health and vitality of a higher education system that has served this Nation well.

Sincerely yours,

David Packard
Chairman
Panel on the Health of
U.S. Universities

White House Science Council

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White House Science Council Panel on the Health of U.S. Colleges and Universities

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Deputy Director
Office of Science and Technology Policy

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PREAMBLE

America has a unique dependence upon its colleges and universities both for new knowledge and for young minds trained to use this knowledge in innovative ways, the excellence of our colleges and universities has been a cornerstone of our economic well being, our national security, and the health and quality of life of our citizens But, as emphasized by the White House Science Council Panel on the Health of U S Colleges and Universities, the strength and excellence of this higher education enterprise is at a transition point, and can no longer be taken for granted

At a time when ever greater demands are being made on our research universities they find themselves, after more than a decade of belt tightening and retrenchment, with aging facilities, obsolete equipment and growing shortages of both faculty and students in many important areas

The problems discussed in this Panel Report are very real and very important And the Panel is entirely correct in its conclusion that increased support, important as that will be, is not, in itself, sufficient to ensure the health of our system of higher education What is most needed is a re examination and restructuring of the relationships that have evolved among the federal government, the universities, and U S industries

Recognizing the powerful dividends, both short- and long-term, reaped from our universities and colleges, many sectors of society—including state governments, industry, foundations and private individuals—have increased their support of educational institutions in recent years This commendable commitment to sustained academic excellence reflects a recognition that, just as these benefits accrue to all, so also must the costs be shared by all

This Administration has made a concerted effort to maintain the Nation's preeminence in an age of rapid technological change and intense international competition This is evident in the broad measures taken to spur continued economic growth and competitiveness, including reducing the federal deficit, reducing taxes and eliminating unnecessary regulation It is also reflected in this Administration's provision of increased real funding for basic scientific and engineering research, totaling 30 percent since 1981, especially in our colleges and universities

As the Panel emphasizes, however, while these actions have been critically important, much remains to be done to offset the neglect of the prior decade It is essential that we return to the view that federal—and industrial—support of university research and education is an investment in our national future rather than procurement of necessary products and services Moreover, while the returns from basic research may in some cases be long-term, that represented by the flow of young scientists and engineers trained in the course of this research is immediate and of critical importance

The Panel presents us with a detailed and careful analysis of the need to develop an effective government-university-industry partnership if we are to maintain our position in an increasingly technological and increasingly competitive world They have made specific recommendations to this end and to the maintenance of the health and vitality of our universities and colleges

I believe that their Report deserves the thoughtful consideration of every citizen, and I share the Panel's optimism that, given the partnership and the support recommended, our universities will respond enthusiastically and effectively to the challenges ahead This report provides an important frame of reference against which to measure our progress and chart our national course

The road ahead will not be an easy one; but it is the road that, for the national good, we must pursue Scientists and engineers have a special responsibility to inform themselves about the issues addressed in this Report and then, as individuals, to take action in support of a strong and vital national science and technology base

The Panel has devoted much thought and effort to their Report, and I would take this opportunity to express to its members my deep appreciation I take pleasure in commending this Report to all readers—scientist and nonscientist alike—as an important contribution to the charting of our national future.

John P McTague
Acting Science Advisor to the President

I. EXECUTIVE SUMMARY

1. Overview

The health of U S society is uniquely coupled to that of its universities To a greater degree than any other country this Nation looks to its universities both for new knowledge and for young trained minds prepared to use it effectively But just at a time when much is expected of our universities, after more than a decade of retrenchment and belt tightening, they find themselves with obsolete equipment, aging facilities, and growing shortages of both faculty members and students in many important fields

In response to a request from former Science Advisor to the President, George A Keyworth, for recommendations on how to ensure the universities' long-term ability to provide the talent and research necessary for the Nation's scientific enterprise, the White House Science Council established the Panel on the Health of U S Colleges and Universities Its membership includes representatives from the research community, both academic and nonacademic This report is the result of their study

To assess the university system's future, the Panel asked—among others—the following questions Are our universities attracting the best students into science and engineering? Is the education and training provided adequate to prepare the next generation of scientists and engineers for the challenges of the 21st century? Will our universities be able to respond appropriately as these demands change? Do the environment and support allow researchers to be optimally productive?

The answers to these questions cause us concern The problems are real and ubiquitous

We are certainly not alone in recognizing that science and technology are critical to our future Nations everywhere are investing in these capabilities We conclude that we must rethink and, in many ways, rebuild the critically important interactions between universities, government, and industry that have served this Nation so well in the past The federal government-university relationship is too fundamental to the maintenance of our national science and technology base to be taken for granted, and the industry-university partnership is emerging as critical to exploiting that base in order to compete in the world marketplace

One conclusion is clear: our universities today simply cannot respond to society's expectations for them or discharge their national responsibilities in research and education without substantially increased support. Federal support of university research as a percentage of the gross national product peaked in 1968 and reached a low point in 1978 After increases in 1979 and 1980, it has declined in the 1980's (Figure 1) In 1984, only $8 billion of the nearly $100 billion in total national research and development was performed in universities, a level that simply does not reflect our dependence on the availability of the most able technical talent An economy whose growth prospects depend upon maintaining a competitive edge in technology must look to an increasing—not decreasing—emphasis on the source of this technical talent It is time to take an honest look at what the real costs of university-based research are and how they should be borne We must return to the viewpoint that federal support of such research is a long-term investment in the Nation's future rather than the procurement of a necessary product

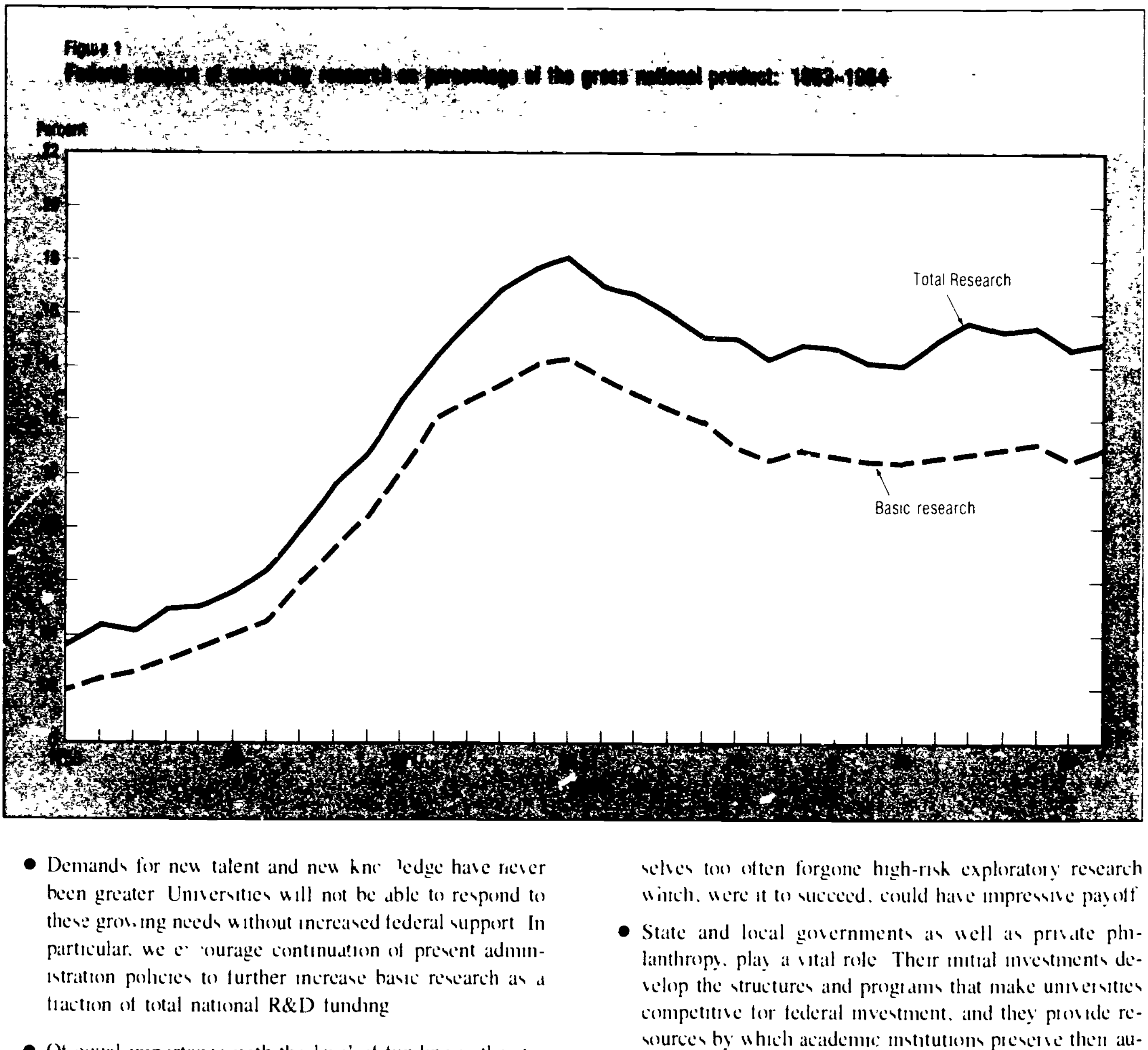
The strength of the nation in trade, defense, and health has been directly related to past investments in science and technology Our future position in global markets will similarly depend on our willingness to respond to opportunity and to mobilize our strengths today To this end, we must promote a broad interdisciplinary approach to problem-solving by focusing on university-based centers that will improve cooperative linkages between scientists, engineers, and industry

If we are to have an acceptable future in an increasingly technological and competitive world, and if we are to respond adequately to national needs in areas of economic competitiveness, national security, and quality of life for all our citizens, the time has come when a new partnership involving all three, the federal government, universities and the private sector, must be forged And we must be realistic about the very real limitations on the extent to which industrial support of basic research, important as it is, can replace that from the federal government

In the summary which follows, we present the Panel's major findings and recommendations. We believe that they demand the attention of the nation, and that if they are implemented, our universities will respond enthusiastically and effectively. Our present leadership in international science and technology is challenged, indeed, many consider it fragile and endangered. We are confident that the actions we recommend will allow us to retain this leadership We cannot afford less

2. Findings

- A healthy university system is the basis for our future In any ranking of priorities for allocating R&D support—both federal and private—universities must rank first



- Demands for new talent and new knowledge have never been greater. Universities will not be able to respond to these growing needs without increased federal support. In particular, we encourage continuation of present administration policies to further increase basic research as a fraction of total national R&D funding.

- Of equal importance with the level of funding is the stabilization of federal support to permit more effective use of financial and human resources. The most ambitious research requires long lead times for preparation and incubation. Research groups are exceedingly fragile; once disbanded, they can rarely be reassembled. In the absence of stability and predictability, important opportunities have been lost, scarce resources have been used inefficiently and, most serious, some of the brightest young minds in each recent generation have been lost to science and technology.

- The universities themselves must share the responsibility for the deterioration of their health and capability. In attempting to ride out what were hoped to be temporary budget shortfalls, they mortgaged their research futures too often using limited funds to maintain research personnel rather than investing in needed instrumentation or facilities. Moreover, research faculty members have themselves too often forgone high-risk exploratory research which, were it to succeed, could have impressive payoff.

- State and local governments as well as private philanthropy, play a vital role. Their initial investments develop the structures and programs that make universities competitive for federal investment, and they provide resources by which academic institutions preserve their autonomy and diversity. Moreover, such support is a major element of the shared responsibility that typifies the present university-federal government partnership.

- The diversity of our college and university system is an essential element of its strength.

- In recognition of the leadership demands that our society will place upon them, it is essential that mechanisms be developed for early identification and support of our most able youth.

- Strong university-government-industry partnerships are fundamental to meeting our goals in economic competitiveness, national security, agriculture, health, and in improving the quality of life of our citizens.

3. Recommendations

A. To maintain the strong science base essential to our national future, we recommend that:

1. The federal government make substantially greater investments in our centers of learning in the 1980's and 1990's than the 1970's. The recommendations set forth in this report, if they are to be implemented fully, require significant increases in financial support. The source of such funding in these times of fiscal stringency is not obvious. Reallocation of R&D appropriations appears to be the most probable source, but we believe that incremental new funding will be required. In any case, we emphasize that this federal investment, at minimum, must keep pace with the overall national investment in R&D; at the current rate of growth it will double in ten years. More rapid growth is essential if our universities are to meet the burgeoning demands being made upon them from almost every sector of our society. The federal government is the only practical source of funding for the major part of this growth.

2. The federal government support a major initiative to establish university-based interdisciplinary, problem-oriented research and technology centers directed to problems of broad national needs and relevant to industrial technology.

3. The federal government bear its full share of the cost of the university research it supports.

B. To build a solid partnership among the federal government, industry, and universities; to enable the university infrastructures to keep pace with research and educational needs; and to assure that the universities are able to pursue research and education effectively, we recommend that:

1. Federal policies recognize that the costs of university research facilities and equipment are a necessary part of federally sponsored, university-based research costs.

2. The portion of federal research grants and contracts that reimburse universities for use or depreciation of facilities and equipment (use allowances) be based on realistic useful lifetimes.
   a. Useful life of buildings and facilities should be reduced from the present level of 50 years to 20 years.
   b. Useful life of equipment and instrumentation should be reduced from the present level of 15 years to 5 to 10 years, depending on the class of equipment.

   These changes, which do no more than inject reality into the costs of doing research, will increase substantially the indirect fraction of total costs. This increase should not be drawn from direct research costs but from reallocation of funds from other sources.

3. To allow U.S. universities to restore their infrastructures in a timely fashion, a facilities fund be established within NSF for each of the next ten years. And that in order to encourage excellence:
   a. All proposals submitted to this facilities fund should be subjected to peer review within the scientific or technological community involved, and
   b. All awards from the fund should be made on a 50/50 matching basis with non-federal funding.

4. Any reorganization of the federal tax code recognize the importance of increased industry-university interaction. A 25 percent nonincremental tax credit should be established for industrial funding of university research and for industry-supported maintenance and servicing of university equipment. A tax deduction equal to the full market value of all industrially contributed equipment should be established.

C. To minimize controversy and friction concerning the reimbursement of indirect costs, we recommend that:

1. Reimbursements for administrative costs within the indirect cost category be fixed at a uniform percentage of modified total direct costs. That percentage should be the mean national percentage over a five-year historical period, and the adjustments should be phased in over a two-year period to allow those universities now charging more than the new fixed rate to plan for reduction. This change will eliminate much of the need for faculty effort reporting.

2. The formal requirement for cost-sharing be eliminated.

3. The paperwork burden associated with grant and contract administration be reduced to a minimum. In the Panel's view, all faculty effort reporting should be eliminated.

4. All federal agencies supporting university research adopt the NSF practice of including the indirect costs in the project budget subject to peer review.

D. In order that the university environment be conducive to high-quality research and education; that it be attractive to the best minds; and to increase the effectiveness with which federal funding is used for research, we recommend that:

1. Federal agencies work toward an average grant or contract duration of at least three, and preferably five, years.

2. Investigators be free to use up to 10 percent of their grant or contract support on a fully discretionary basis and be permitted to carry unexpended funds forward from one fiscal year to the next.

3. Federal agencies make greater use of block grants or contracts to support groups of investigators having shared research interests.

4. For greater flexibility, to facilitate changes in an investigator's field of research, and to support high-risk research, federal agencies, except in the cases of young investigators, place substantially more emphasis upon the research history of the investigator and less on the proposed research project in making awards.

E. To identify and educate our most talented youth more effectively, and to enable experienced scientists and engineers to continue to contribute their skills in a changing technological environment, we recommend that:

1. A substantial program of merit-based, portable scholarships be established by the federal government at the undergraduate level. Parallel programs should be established by industries having significant dependence upon university research and education. The national goal should be for the most able 1 percent of the undergraduate students in mathematics, engineering, and the natural sciences entering colleges or universities each year to be supported under these programs. This program is recommended as an addition to, not a substitution for, existing need-based federal assistance programs.

2. Substantial programs of multiyear merit-based fellowships, both federal and industrial, be established in science, mathematics, and engineering at the graduate level. Reflecting national needs, the field distribution of these fellowships would be expected to change over time.

3. Universities encourage interdisciplinary activities at the graduate level while retaining the essential quality control function now played by the traditional disciplinary departments.

4. Industries and universities develop attractive continuing education programs for engineers and scientists that are matched to contemporary industrial requirements and to modern science and technology.

II. INTRODUCTION

On the wisdom with which we bring science to bear in the war against disease, in the creation of new industries and in the strengthening of our Armed Forces depends in large measure our future as a nation

Vannevar Bush
Science, The Endless Frontier
p 194

How we, as a nation, succeed in achieving our goals in matters of health, economic strength and national security will depend critically on how effectively we deploy our science and technology. This, in turn, depends upon the strength of our science and technology base—upon the flow of new knowledge and of trained personnel equipped to utilize that knowledge effectively. As was vividly demonstrated in the radar, atomic energy and medical care advances during World War II, technological developments draw upon a reservoir of basic research in science and engineering, and upon the imagination and creativity of broadly educated scientists and engineers. Indeed, our society's recognition of this dependence underlies the federal support which has given us, in the U S , one of the world's strongest science and technology enterprises

Both science and technology are advancing at an unprecedented pace and are strongly affecting the daily lives of our citizens, rarely, if ever before, have such revolutionary changes and advances occurred simultaneously across the entire spectrum of the sciences. Such rapid change poses fundamental challenges and equally fundamental opportunities. If we are to respond effectively to these challenges and opportunities, we need, more than ever, an increasing flow of new knowledge and of trained personnel—a stronger national science and technology base. In this country, we are uniquely dependent upon our universities for both basic research and higher education, perhaps our greatest strength here has been our insistence that the two are inseparable and symbiotic

But just when much is expected of our universities, many have expressed growing concern about their ability to respond to national needs. The comments we have received from leaders in universities, industry, and government suggest that there are serious problems in the availability of modern research instrumentation and facilities, that overall funding levels are too low to provide appropriate stability to existing research groups as well as allow the entry of promising young investigators, that government regulations impose unnecessary administrative and accounting burdens, and that training in many fields is inadequate for societal needs. Despite increased support in recent years, after more than a decade of level funding, of growing friction in the federal government-university interaction, of inadequate industry-university communication or cooperation, and of student and faculty shortages in many critical fields, the U S university system, long the envy of the world, is now under stress. The White House Science Council Panel on the Health of U S Colleges and Universities was appointed by Dr. Solomon J. Buchsbaum, Chairman of the Council, and by Dr. George A. Keyworth, Science Advisor to the President, and was charged with an examination of the present health of our university system and with the formulation of policy recommendations designed to ensure that our universities would be able to respond to the growing national demands upon them

In our study, we have focused upon the natural sciences and engineering, but the health of the entire spectrum of American education—from chemistry to computer science to the classics—is important to our national future. In a society of ever increasing scientific and technical complexity, effective citizen participation requires a degree of scientific and technological literacy that allows appreciation of the central issues involved, if not direct participation in their resolution. On the other hand, the Nation can ill afford generations of scientists and engineers unable to appreciate the economic and social consequences of their work or the underpinning of values and moral judgments that are the primary focus of the humanist

The reader will find in this Report a brief discussion of the need for university-based research (Chapter IV). In Chapter V, we focus upon the costs of academic science and engineering, with particular reference to the question of indirect costs which have been a root cause of much of the growing friction and alienation between universities and the federal government. Finally, in Chapter VI, we consider the environment for academic science and education, and the opportunities and responsibilities that government, industry, and the universities each face in making it more effective

After each of these chapters, we collect our primary findings and recommendations for the reader's convenience, the major ones are again presented in the second part of our Executive Summary

III. THE NEED FOR UNIVERSITY-BASED RESEARCH

The value of fundamental research does not lie only in the ideas it produces. There is more to it. It affects the whole intellectual life of a nation by determining its way of thinking and the standards by which actions and intellectual production are judged . . . An atmosphere of creativity is established which permeates every cultural frontier. Applied science and technology are forced to adjust themselves to the highest intellectual standards which are developed in the basic sciences . . . Fundamental research sets the standards of modern scientific thought; it creates the intellectual climate in which our modern civilization flourishes. It pumps the lifeblood of idea and inventiveness not only into the technological laboratories and factories, but into every cultural activity of our time. The case for generous support for pure and fundamental science is as simple as that.

V. F. Weisskopf
Bulletin of the Atomic Scientists
April 1965

1. Introduction

From the beginning of this nation, its genius has been the speedy and effective conversion of new knowledge into useful goods and services. In our earliest days we tended to draw upon the reservoirs of basic discovery filled elsewhere—particularly in Europe; our aim was its conversion to practical use. Our focus was on the mastery of nature rather than its understanding—on invention rather than natural philosophy—and the two were considered quite distinct and separable until the pressures of World War II demonstrated their intricate and essential connections. These connections can be subtle and indirect. Basic research—the understanding of nature—is not necessarily linked to any specific technological orientation; the engineer or technologist cannot tell in advance what basic research result may be of greatest relevance to his work. Some basic research—that leading to X-rays, for example—may find important medical and technological applications within months of the original discovery. This, however, is not the common experience. Much basic research is not translated into application for decades after discovery.

Reflecting the enormous spread in lag times between discovery and application, it is very difficult, if not impossible, to document a very general visceral feeling shared by the Panel members and by a very large fraction of the scientific and technical community that the process of utilization—the transfer of new knowledge into goods and services—is accelerating. This may not reflect a change in the fundamental mechanisms whereby these transfers are accomplished, but rather a rapidly growing recognition of the potential benefits to be derived from the possible applications of scientific and engineering discoveries and the increase in the number of individuals qualified to, and interested in, making such applications.

This is more obvious when we consider the international marketplace in which we now function. For several decades following World War II, the U.S. set the style and pace of scientific and technological activities worldwide. We chose those areas which were to receive emphasis. This situation is now dramatically different, not because of any slackening on our part, but simply because the rest of the world is catching up, and, in a few areas, surpassing us in the ability to discover and exploit new knowledge.

It has become increasingly important that the basic research reservoirs from which *all* draw in a technological world be kept filled for use by engineers and scientists devoted to the production of goods and services for society. The interaction between basic science and technology is one of symbiosis. Basic science has continued to press the frontiers of knowledge and at the same time has been dependent upon the skill and ingenuity of engineers for its progress. By participating in the achievement of national goals, basic research is made no less pure, no less exciting; it is, however, made more challenging, more rewarding, and more important when better appreciated and better utilized.

Basic science frequently finds entirely new challenges and new directions from the needs of the world. There are many examples from which we select three: DNA in biology was discovered as the outcome of a study of the scourge of pneumonia; complexity theory in abstract mathematics was discovered as an outcome of attempts to understand the functioning of simple electronic computers; and universal cosmic black body radiation in astrophysics was discovered as the outcome of an attempt to understand the source of noise in satellite communications systems

It is the combination of new knowledge from basic research and of minds that can appreciate the practical applications that provide the most fertile source of innovation

2. Graduate Education and Research

As graduate education flowered in this country's universities in the latter part of the nineteenth and early part of the twentieth centuries its industrial support flowed from a recognition of the universities' importance in the education of scientists and engineers and the discovery of new knowledge. Both were understood as essential to progress It was only with World War II, however—and the scientific and engineering triumphs of radar, atomic energy, medical care and the like—that U S society more fully recognized the importance of basic research and, more particularly, its potential importance in matters of health, national security and economic strength It is this recognition that lay behind the subsequent great increase in federal support of U S university research activity.

From the outset of graduate education in the U S , particularly in science and engineering, an intimate connection between education and research has been considered fundamental to the production of creative scientists and engineers Our focus on this linkage has served the Nation well Very much a part of this focus is the fact that most of U S. basic research is conducted in our universities, making these universities critical to our national science and technology enterprise A strong confirmation of the effectiveness of our university system indeed comes from the number of foreign students studying science and engineering in this country

Since most basic research can rarely be perceived in terms of specific products and services, and given the long-range nature of such research, private industry does not often support a high level of basic research If one thing has become clear in recent decades, it is that the fruits of basic research provide benefits for all of society, frequently in ways not visible initially to any of the participants. It is for these reasons that the federal government has become, and remains, the primary supporter of basic research in this country

3. Federal Support of University Research

The major surge in federal support for scientific research in universities came as a consequence of the experiences of the Second World War In particular, the prewar-postwar transition is epitomized by the report *Science, the Endless Frontier*, and the agency to which it led, the National Science Foundation (NSF). The report, prepared by Vannevar Bush in 1945 at the request of President Truman, for the first time articulated a federal policy which accepted responsibility for the support of research, and of basic research in particular Establishment of NSF in 1950 was the logical outcome of this policy. In contrast to the targeted support of mission agencies, the National Science Foundation Act of 1950 directed that the objective of the Foundation be ". . . to strengthen research and education in the sciences, including independent research by individuals . . ."

This language clearly indicated that the purpose of federal involvement should be in the nature of an *investment* in research Spurred also by Sputnik in 1957, the result was a strong influx of funds into R&D generally and into the universities specifically As shown in Table 1 and Figure 2, from 1953 to 1961 federal funding of R&D increased 14 percent annually, in constant dollars The rate of increase in federal funding at universities reached its peak between 1958 and 1964, increasing an average 21 8 percent annually, in constant dollars (Figure 3)

In 1968-1969 however, growth came abruptly to a halt, and for the next decade showed essentially no increase in real terms Although the universities increased their own expenditures in R&D almost 50 percent during this period (Figure 4), this could not even come close to providing a reasonable rate of growth for the system

In parallel with this halt in funding, was a halt in the growth of manpower engaged in university R&D Between 1954 and 1968, full-time scientists and engineers engaged in R&D at universities increased more than two-fold and the graduate student population more than tripled. However, between 1968 and 1974 growth in these groups was essentially zero (Table 2)

The damage resulting from this long period of stasis and decay cannot be overestimated. Since universities conduct more than 60 percent of the basic research performed in this country, the absence of growth was reflected in a significant deterioration in this nation's ability to promote technological advances In an era when science and technology are the key to economic success, such a decline implies a drop in the standard of living of all members of the society, and indeed poses a threat to the future of this country in international competitiveness

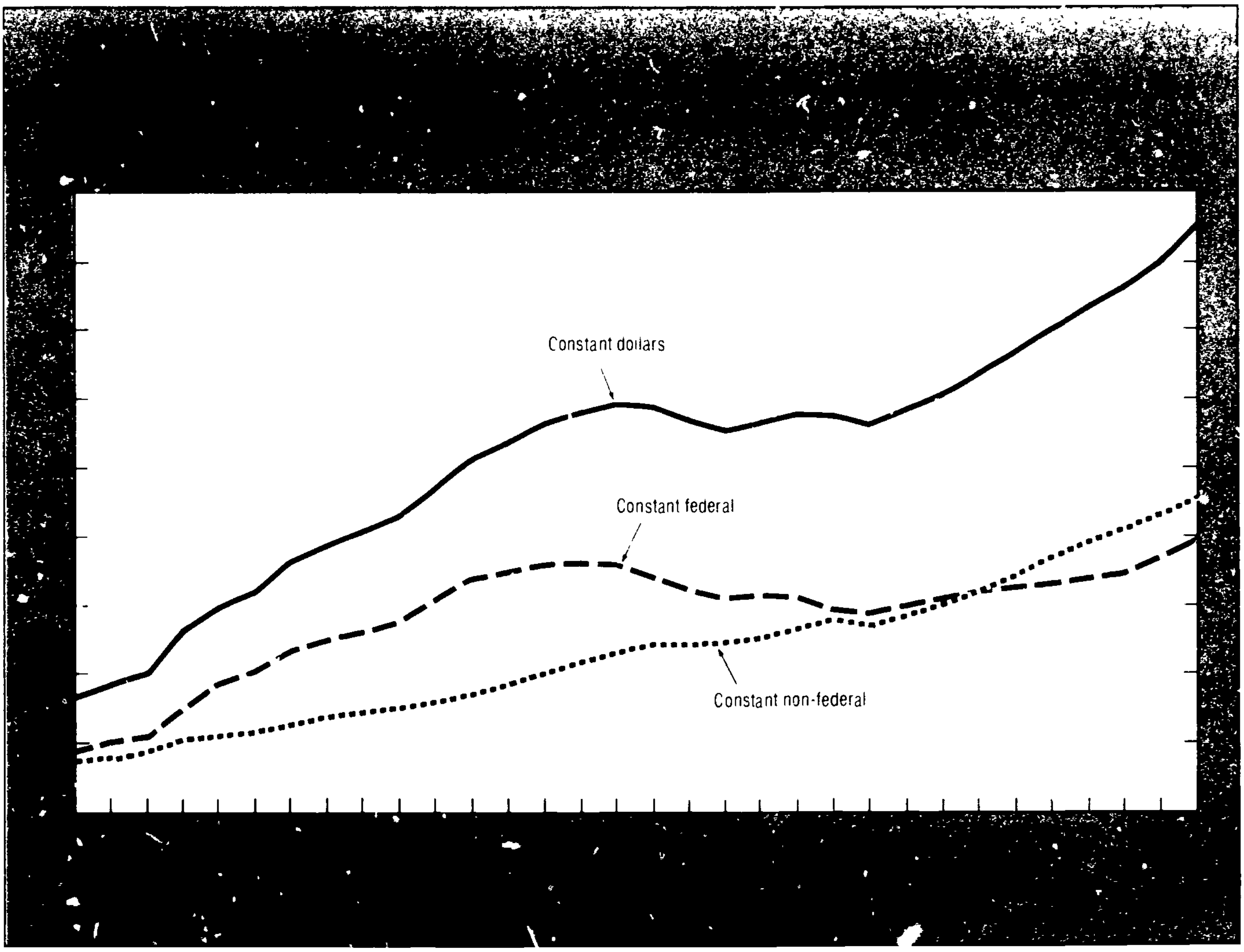
No less serious is the loss of trained manpower, and for the same reasons Graduate training is essential to providing industry, academia, and the federal establishments with individuals capable of initiating, exploiting, and maintaining technological advances And even beyond this, the limitations on the universities' ability to provide educational opportunities adequate in either scope or quality limited the ability of a significant proportion of our youth to reach their full potential This represents a tragic loss not only for the individuals involved, but also for society as a whole.

During this period of stagnation, several specific phenomena occurred which have affected the capabilities of the universities to this day. Direct federal support of R&D plant in the univer-

Table 1: Average Annual Change in National R&D Funding 1953-1984
(In Percent)

	Current Dollars			Constant Dollars		
Year	Total	Federal	Non-Federal	Total	Federal	Non-Federal
1953-61	13.7%	16.4%	10.0%	11.4%	14.0%	7.7%
1961-67	8.3	7.6	9.5	6.0	5.3	7.2
1967-75	5.4	2.9	8.7	7	3.0	2.4
1975-79	10.0	9.1	11.0	3.5	2.6	4.5
1979-84	11.9	10.8	12.7	4.9	3.9	5.9

SOURCE National Science Foundation, *National Patterns of Science and Technology Resources, 1984*



sities dropped from $211.7 million (in 1972 constant dollars) in 1966, to $19.5 million in 1981. In 1966, the percentage of the budget of NIH research grants devoted to instrumentation was 11 7 percent (Figure 5) For NSF, the comparable value in 1966 was 11.2 percent By 1982, this percentage was about 4 5 percent for NIH and 9 percent for NSF Since NIH and NSF have consistantly contributed two-thirds of the federal support for university instrumentation, these decreases clearly have been significant The inadequacy and decay of the physical plant, and the obsolescence of the equipment pool have been extensively documented in recent years (Figure 6) There can be little doubt that they severely limit the research productivity and creativity of the universities

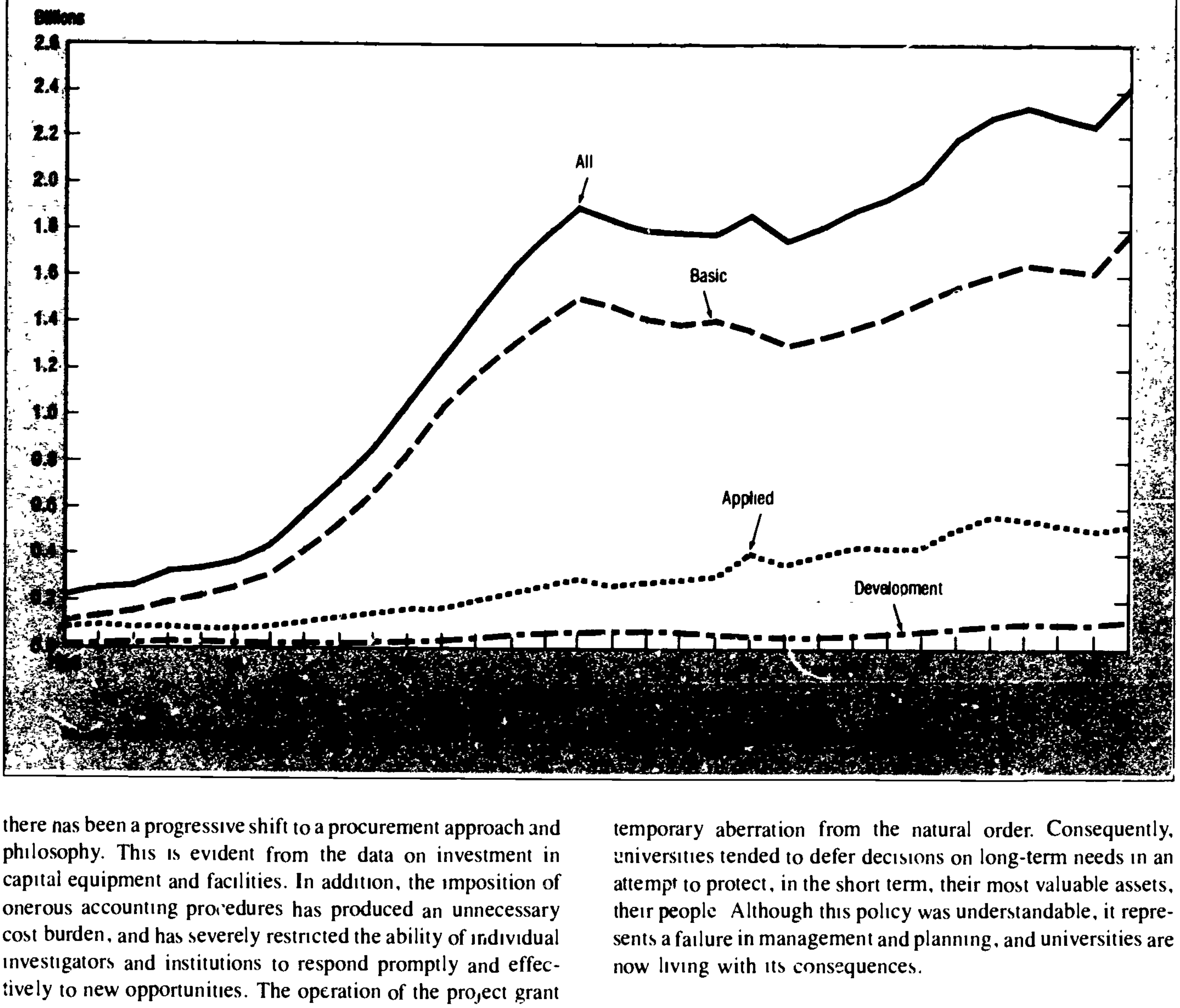
4. Increasing Costs of Research

In addition to the general inflation which affects the broader reaches of society, there is another form of cost increase intrinsic to much research and technological progress Major advances can still result from individual genius and from simple pencil and paper studies, but it is fundamental to the nature of empirical research in any field that each new experiment tends to require more sophisticated equipment, more complex techniques, more adept and creative researchers, and purer materials, for example. This simply reflects the increasing difficulty with which deeper understanding is wrested from nature. It appears in virtually every field of science In medical research, simple X-ray machines that once provided invaluable information to researchers and physicians now are little used, but have been replaced by more capable (and more complex and more expensive) computer-assisted tomography (CAT) scanners and nuclear magnetic resonance (NMR) machines In particle physics, simple bubble chambers are no longer capable of providing new insight to scientists; huge and much more sophisticated detectors with real-time links to very large computers to process huge volumes of new data are required Indeed, in virtually every area of research, investigators now use and require extensive computer time, where not many years ago it simply did not exist Evidence suggests that nonpersonnel costs of high technology R&D have risen some 50 percent faster than has the consumer price index

5. Investment or Procurement?

Perhaps most important, the decline in the growth of federal support coincided with a change in the way the federal government viewed its involvement with universities and university-based research From an emphasis on long-term investment

Figure 3
Federal expenditures on university research: 1963–1984 (constant 1972 dollars in billions)



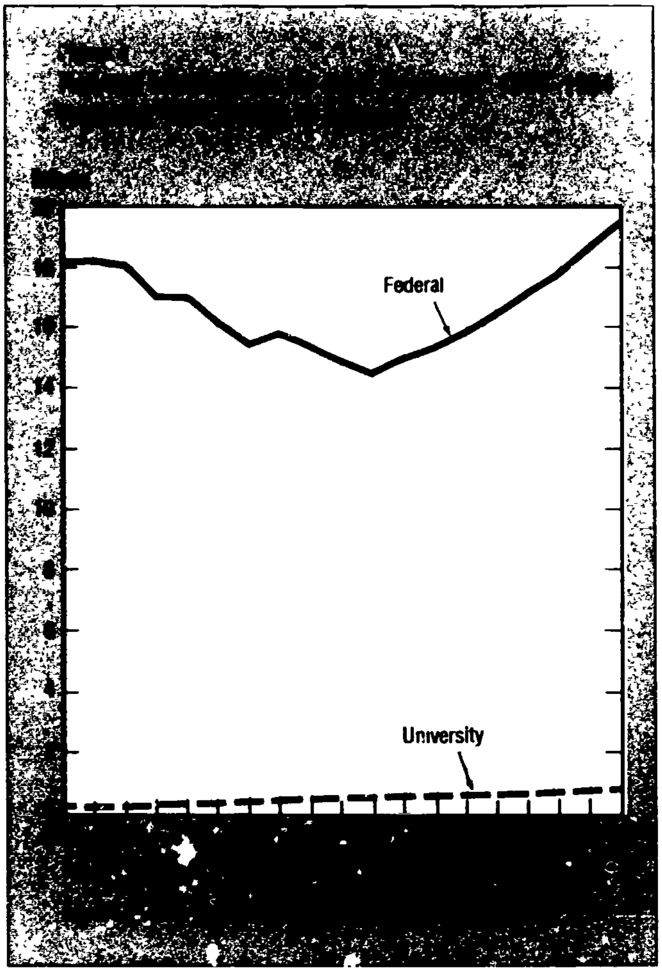
there has been a progressive shift to a procurement approach and philosophy. This is evident from the data on investment in capital equipment and facilities. In addition, the imposition of onerous accounting procedures has produced an unnecessary cost burden, and has severely restricted the ability of individual investigators and institutions to respond promptly and effectively to new opportunities. The operation of the project grant system has shifted from primary reliance on the capabilities and vision of talented investigators, to insistence on the detailed presentation and achievement of specific goals.

This lack of trust and confidence in our investigators and research institutions appears to the Panel to be totally unjustified. The university system has served this country well in its primary missions—the conduct of basic research and the training of young minds. The adversarial relationship which has developed in many areas of university-government relations, as in assessment of indirect costs (see next chapter), is damaging both parties in their common pursuit of the goal of a better national future.

It must also be said, however, that the blame for deterioration in the health of the American university research system must be shared. Universities, by and large, had little choice but to take a short-range perspective in managing their resources. In general, each year's decline in federal support was rationalized as a temporary aberration from the natural order. Consequently, universities tended to defer decisions on long-term needs in an attempt to protect, in the short term, their most valuable assets, their people. Although this policy was understandable, it represents a failure in management and planning, and universities are now living with its consequences.

6. Rebuilding University Research

The decline between 1968 and 1975 in growth of federal funding of research has been reversed in recent years. Beginning in 1975, total federally supported R&D has increased steadily. Between 1981 and 1984, Federal support for R&D increased by 14.3 percent and for basic research by 7.1 percent (per Figure 7). A concentrated effort, however, will be needed during the next few years to sustain these recent support trends. The Panel is unanimous in its view that the Nation's demand for talent and for new knowledge will not be met without a substantially greater federal investment in university research—with much of the increase devoted to upgrading and strengthening of the university research infrastructure. We are convinced, moreover, that this increased investment will require both a new set of priorities for expenditure of federal R&D funds and increased support of university activities.



Currently, only about 20 percent of total federal civilian R&D funding is devoted to the support of basic research in the universities and only about 30 percent to academic research of all kinds. **Of the almost $100 billion expended nationally in 1984 for research and development only about $8 billion found their way to universities. Such a balance is simply not appropriate to today's demands for the talent and new knowledge that only universities can provide.**

Based on all the information available to it, the Panel is convinced that full implementation of the recommendations in this report will require significant increases in financial support for basic research in the universities. The source of such funding in these times of fiscal stringency is not obvious. Reallocation of R&D appropriations appears to be the most probable source, but we believe that incremental new funding will also be required. In any case, we emphasize that future investment in university basic research must at least keep pace with the overall investment in national R&D; at the rate this is currently growing, the investment in real terms will double in ten years. This is simply not adequate to permit the universities to respond effectively to the demands being made upon them from almost every sector of our society. **We must make a greater commitment to our centers of learning in the 1980's than was provided to them in the 1970's, and the federal government must take the lead for the major fraction of that support.**

7. Importance of Stability

It is essential, too, to recognize that stable and predictable growth, not intermittent infusion of funds, is essential Violent

TABLE 2
FULL-TIME EQUIVALENT (FTE) SCIENTISTS AND ENGINEERS EMPLOYED IN RESEARCH AND DEVELOPMENT, BY SECTOR: SELECTED YEARS[1]

Sector	1954	1958	1961	1965	1968	1969	1970	1971	1972	1973	1974	1975[2]
Total	237 1	354 6	425 7	494 1	550 4	558 2	549 6	529.8	521 9	521 1	527 2	530 5
Federal Government[3]	37 7	46 0	51 1	61 8	68 1	69 9	69 8	66 5	65 2	62 3	65.0	64 5
Industry[4 5]	164 1	256 1	312 0	348 4	381 9	385 6	375 5	358 4	353 3	357 4	357 9	358 0
Universities & Colleges total	25 0	36 5	42 4	53 4	66 0	68 3	68 5	68 4	66 5	64 8	66 7	71 0
Scientists and engineers	20 3	29 2	33 6	40 4	49 0	50 4	50 3	49 8	48 9	43 2	49 2	52 6
Graduate students[6]	4 7	7 3	8 8	13 0	17 0	17 9	18 2	18 6	17 6	16 6	17 5	18 4
University associated												
FFRDC's, total	5 0	8 1	9 1	11 1	11 2	11 6	11 5	11 5	11 7	12 0	12 1	12 8
Scientists and engineers	4 9	7 9	8 8	10 7	10 7	11 1	11 0	11 0	11 3	11 7	11 8	12 4
Graduate students[6]	.1	2	3	4	4	5	5	5	4	3	3	4
Other nonprofit institutions[4 7]	5 3	7 9	11 1	19 4	23 2	22 8	24 3	25 0	25 2	24 6	25 5	24 2

[1]Number of full-time employees plus the FTE of part-time employees Excludes scientists and engineers employed in State and local government agencies

[2]Estimate

[3]Includes both civilian and military service personnel and managers of R&D Military R&D scientists and engineers in the Department of Defense were estimated at 7,000 in 1954, 8,400 in 1958, 9,200 in 1961, 12,000 in 1965, 13,000 in 1968, 14,000 in 1969 and 1970, 12.000 in 1971, 10,700 in 1972, 8,100 in 1973, 7,600 in 1974, and 7,700 in 1975

[4]Includes professional R&D personnel employed at FFRDC's administered by organizations in the sector

[5]Excludes social scientists.

[6]Numbers of FTE graduate students receiving stipends and engaged in R&D.

[7]Includes estimate for R&D scientists and engineers employed in State affiliated institutions such as hospitals, museums, etc

NOTE: The figures for the industry sector represent yearly averages and may differ from other data in the text which is based upon surveys reporting the employment in a single month of the year. Data in the text exclude historians, political scientists, and other social scientists

SOURCE National Patterns of R&D Resources

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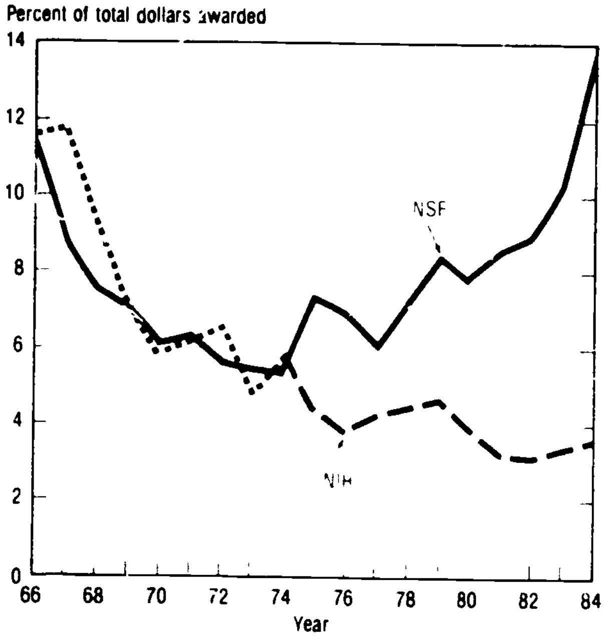
Figure 5

Proportion of NSF and NIH grant funds allocated for permanent laboratory equipment



▪▪ NIH estimate for 1966 through 1974 includes only data from the National Cancer Institute, the National Institute of General Medical Sciences, and the National Heart and Lung Institute.

SOURCE: The NSF data is obtained from *Science Indicators 1974* and Jim Hoehn, personal communication. The NIH data through 1974 is obtained from *Science Indicators 1974*. After 1974 the data is from the internal NIH files and reflects the total contribution of grant funds to equipment.

fluctuations from year to year (and recently even within fiscal years) irrevocably disrupt research groups and programs and effectively halt planning.

Beyond this stable growth in the support of university-based research, additional support is urgently needed to reverse the decay in physical plant and obsolescence in research equipment that has occurred in the past decade. We cannot afford to wait for the slow catch up that would be possible under an acceptable steady-state support scenario.

We believe that the more realistic use allowances for facilities and equipment that we recommend elsewhere in this Report and the recently approved inclusion of the costs of capital in the allowable federal indirect cost recovery pool will provide a significant part of the flow of resources that will enable the universities to maintain and modernize their facilities and equipment, but we emphasize that such resources alone will not suffice.

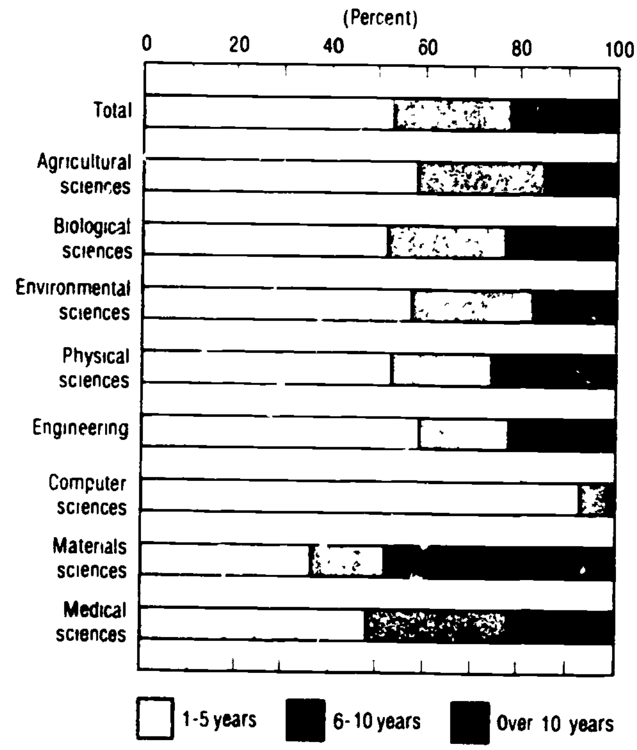
8. Restoring University Infrastructure

Some corrective action is already underway. Federal agencies, encouraged by Congressional concerns, have already initiated new programs to support purchase and renovation of research equipment. We applaud the initiative taken by Representative Fuqua, Chairman of the House Science and Technology Committee, in introducing H.R. 2823, "A Bill to assist in revitalizing the Nation's academic research programs by requiring specified federal agencies to reserve a portion of their research and development funds for the replacement or modernization of laboratories and other research facilities at universities and colleges." We also appreciate the spirit in which this Bill was introduced as a basis for national discussion of this important issue.

The Panel would differ with H.R. 2823 in two important aspects, however. We would recommend that the program be focused in the NSF rather than be distributed across the six major federal R&D agencies in order to minimize bureaucracy and foster uniform standards and procedures. We would also, and more important, recommend that the funding proposed in H.R. 2823 be provided incrementally to the present R&D support levels rather than, as proposed in H.R. 2823, a 10 percent part of the present support levels. As we argue throughout this Report, these present support levels are already inadequate to the national demands on the universities. Given this fact, important as the demands for infrastructure are, were they to be met by an effective 10 percent cut in the level of support for actual

Figure 6

Age distribution of academic research instrument systems: 1982-83

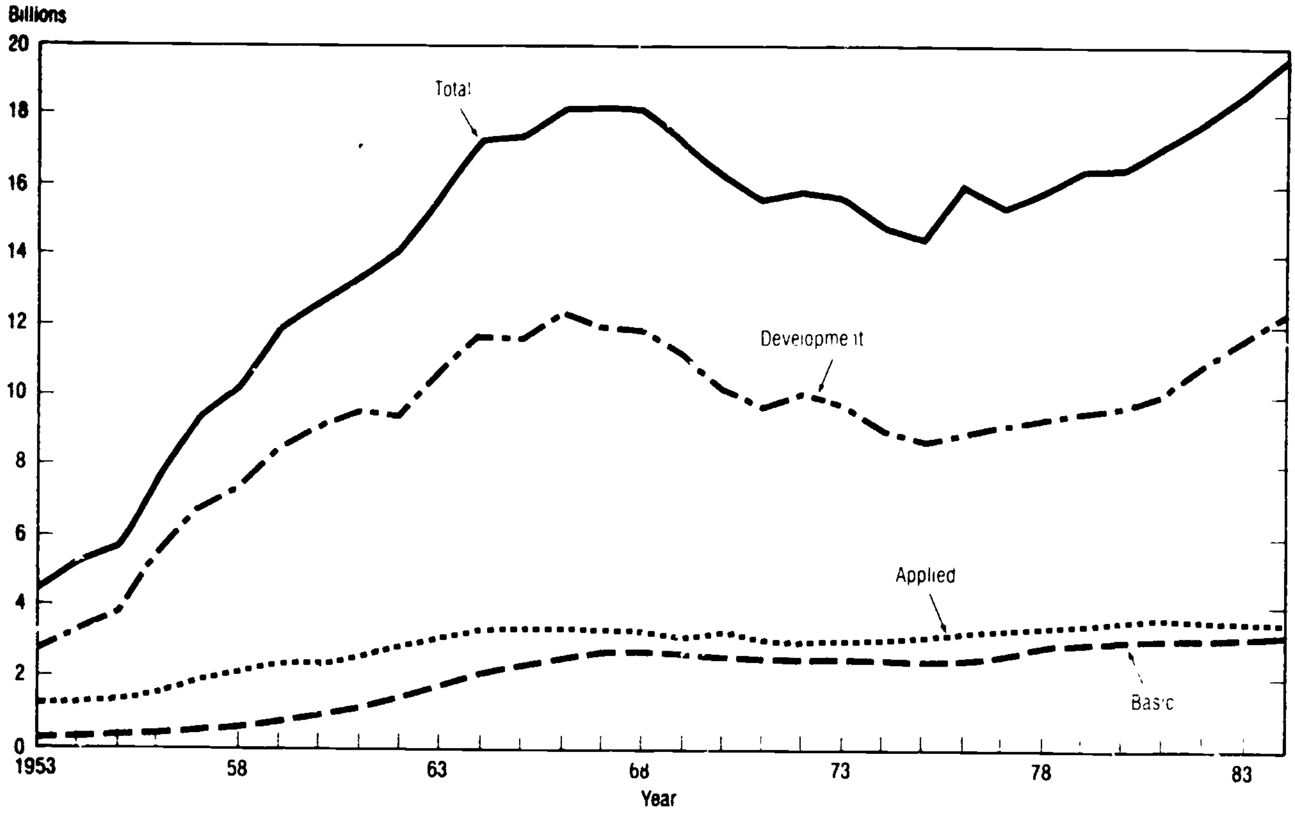


NOTE: All statistics are national estimates encompassing the 157 largest R&D universities and the 92 largest R&D medical schools in the nation. Agricultural, biological and environmental sciences estimates are as of December 1983. For all other fields, estimates are as of December 1982. Sample = 6985 instrument systems.

SOURCE: National Science Foundation, *Academic Research Equipment in the Physical and Computer Sciences and Engineering* (1985) and unpublished tabulations.

Science Indicators—1985

Figure 7
Federal support for research and development: 1953-1984 (constant 1972 dollars in billions)



SOURCE *National Patterns of R&D Resources Funds and Manpower in the United States*, 1953-1975 *National Patterns of Science and Technology Resources* 1984

R&D, the consequences within the university research community would be devastating

We therefore recommend that in order to allow U S universities to bring their infrastructures facilities and equipment - to an acceptable level in timely fashion— to catch up—a temporary facilities fund be established within the NSF, for each of the next ten years In order to encourage excellence we recommend that awards from this fund should be made only on a 50 50 matching basis with non-federal funding and that all proposals submitted to the fund be subjected to peer review within the scientific or technological community involved

The magnitude of the university infrastructure shortfall has been examined extensively in recent years with estimates covering a very wide range Quite independently of the Fuqua initiative, the Panel arrived at the same estimate of the necessary minimum program scope—$10 billion over the next 10 years with $5 billion from federal and $5 billion from non-federal sources

9. Realistic Use Allowance

Although a facilities fund is required for "catch-up" purposes, once again efforts must be made to ensure that the program provides continuous support to prevent the boom bust syndrome of the past In order to encourage continuity and stability in this area as well, the panel recommends that the average useful life of university buildings and facilities be recognized as being closer to 20 years, compared to the current assumption of 50 years Similarly, the useful life of equipment and instrumentation should be considered as 5-10 years depending on the class of equipment, compared to the present level of 15 years This should be translated into the appropriate levels of use allowance in the negotiated indirect costs, thereby allowing an appropriate recovery of funds to allow continuing maintenance and construction, as necessary in the universities

We further recommend that reimbursements for interest on borrowed capital (which is now incorporated into total acquisition cost of a laboratory or instrument) should be made a separate category in the OMB A-21 directive on indirect costs. This separation will avoid any possibility of misunderstanding as this relatively new component of allowable indirect costs increases rapidly with the initiation of more university renovation and building

10. Relationship with Industry

It is clear that the government-university interactions have had considerable impact on both participants Industry-university interactions, as noted earlier, have been much more limited and, except in unique cases, of much less importance

Industry has long had direct links with universities, usually on a one-to-one basis, with some fields having closer relationships than others. But these relationships have depended, in large part, on very unique individuals, and their practices were not widely copied in either U.S. industry or the universities Much more widespread, of course, are individual faculty consulting relationships.

During the late seventies, however, it began to be recognized that the pace of international technological change required a greater awareness by U.S. industry of university research developments. Moreover, widespread predictions of growing shortages of qualified electronics engineers and computer scientists, and indeed shortages in almost all engineering, mathematics and physical science disciplines, led many companies to reconsider their university ties and their roles in university affairs. While their actual direct research funding levels in support of university activities are still less than 10 percent of the federal government's, industry has begun to develop a wide range of mechanisms for interacting with universities. Particularly important is the assistance that industry can give in providing information to university researchers on areas of basic research that may form the background to the solution of recognized current or future practical problems. In this context, cooperative research through individual contracts, industrial affiliates programs and university cooperative research centers have all received growing attention and support. The federal government has attempted to support these trends by joint funding of cooperative research programs and by supporting innovative new university problem-solving centers.

Perhaps most important of all in the growing rapprochement of U.S. industries and universities is the dissipation of stereotypes developed during the postwar years of readily available federal funds for universities. Both industry and the universities were diminished and weakened by the breakdown, during this period, of their former interactions and channels of communication. Industry can, and must, bring to universities a renewed appreciation of the challenges and opportunities that exist in industry and in the international marketplace, universities, in turn can, and must, bring to their industrial partners a renewed appreciation of the contributions that well-trained, bright young minds—as well as the fruits of university-based research—can make to retaining for U.S. industry a leadership role in a rapidly evolving, increasingly technological, and increasingly competitive world. Industries are thus finding themselves dependent upon the university system for both talent and new knowledge, the products of university education and research activity. Current industrial support of the universities, however, does not measure up to this dependence.

The Panel believes that the federal government can—and should—act to promote greater industrial participation in university activities and that such participation is very much in the national interest. We therefore recommend that a 25% R&D tax credit should be extended to cover fully industrial research expenditures in academic institutions We further recommend that this deduction should not be incremental but rather a full deduction and that a tax deduction for the full market value of equipment contributed to academic institutions should be established.

11. Multidisciplinary Science and Technology Centers

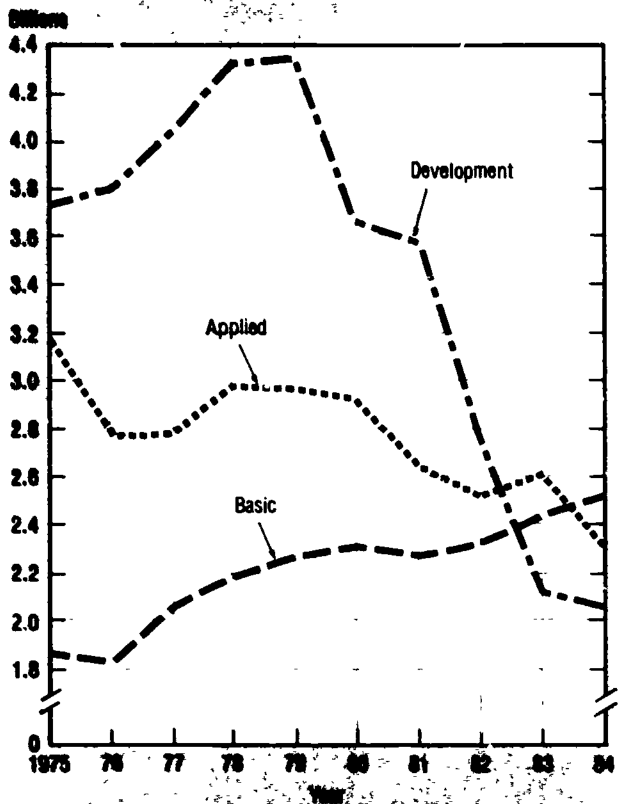
Of greatest importance, however, is the need to use the existing strengths of both the universities and industry jointly to address problems of long-range national scope In order to ensure that we can recognize and seize technological opportunity, we must create a research environment that can facilitate change across disciplinary boundaries. A first step has been taken in that direction through the formation, at NSF, of multidisciplinary problem-oriented engineering centers. It is necessary now to expand this concept from the narrow engineering focus to the broader view of science and technology centers.

Much of the most exciting research to be undertaken in the future will not fall within the traditional natural science disciplines. As the questions relating to science and technology become more complex, and demand teams of researchers with a broad range of expertise, it will be to the Nation's advantage to provide multidisciplinary centers for their solution. Indeed, it is increasingly the case that the most exciting and fruitful research opportunities are to be found in the interface areas between the traditional disciplines. As presently constituted, the universities cannot comfortably accommodate interdisciplinary research. It will be important for the federal government to provide funding to enhance these interdisciplinary activities within the universities

The rationale for such an approach has already been stated, but is worth repeating. Emerging technologies are the foundation of industrial competitiveness, and depend heavily on future developments in basic research. Consequently, we find the demand for trained manpower and effective knowledge-transfer growing steadily. This can be most effectively stimulated by the federal government through support for "strategic research," i.e., basic research carried out with the expectation that it will provide a broad base of knowledge necessary as the background for the solution of recognized practical problems.

An emphasis on basic research is consistent with recent government policy. In 1981, development was the largest part of the non-defense federal R&D budget, and basic research was the smallest. By 1984, that ratio had completely reversed (Figure 8). We support such a policy, and would recommend a major initiative in the federal support of basic research in universities through the establishment of research and technology centers directed to problems of broad national needs and relevant to industrial technology.

In making this recommendation, it bears emphasis that a number of universities have already accumulated substantial experience over many years in bringing together federal, industrial, and university interests in collaborative research projects and centers; it is important that the lessons to be derived from this experience be incorporated in all new initiatives in this area. Much basic research does not lend itself to the large-center approach; preservation of the natural diversity of the basic research enterprise is essential. It will also be important to recognize and make due allowances for those areas of basic



research that may either in fact or in perception appear to be displaced or frozen out by the larger, more newsworthy, or more topical center activities.

Despite the substantial increases in industry participation in university-based research in recent years, it should be noted that the supply of industry resources for—and of industry interest in—such activities cannot be expanded indefinitely. It is essential that this be borne firmly in mind in responding to university initiatives for the creation of new science and technology centers

12. Recommendations

1. The federal government should make substantially greater investments in our centers of learning in the 1980's and 1990's than in the 1970's. The recommendations set forth in this report, if they are to be implemented fully, require significant increases in financial support. The source of such funding in these times of fiscal stringency is not obvious. Reallocation of R&D appropriations appears to be the most probable source, but we believe that incremental new funding will be required. In any case, we emphasize that this federal investment, at minimum, must keep pace with the overall national investment in R&D, at the current rate of growth it will double in ten years. More rapid growth is essential if our universities are to meet the burgeoning demands being made upon them from almost every sector of our society The federal government is the only practical source of funding for the major part of this growth

2. The investment approach to university research, recognizing and contributing to the long-term health of the university research system, must be maintained through stable and continued support.

3. The federal government should support a major initiative to establish university-based interdisciplinary, problem-oriented research and technology centers directed to problems of broad national needs and relevant to industrial technology

4. Federal policies should recognize that the costs of university research facilities and equipment are a necessary part of federally sponsored, university-based research costs.

5. The portion of federal research grants and contracts that reimburse universities for use or depreciation of facilities and equipment (use allowances) should be based on realistic useful life-times:
   a. Useful life of university buildings and facilities should be reduced from the present level of 50 years to 20 years.
   b. Useful life of equipment and instrumentation should be reduced from the present level of 15 years to 5 to 10 years, depending on the class of equipment.

   These changes, which do no more than inject reality into the costs of doing research, will increase substantially the indirect fraction of total costs. This increase should not be drawn from direct research costs but from reallocation of funds from other sources.

6. To allow U.S. universities to restore their infrastructures in timely fashion, a facilities fund should be established within NSF for each of the next ten years. And that in order to encourage excellence:
   a. All proposals submitted to this facilities fund should be subjected to peer review within the scientific or technological community involved, and
   b. All awards from the fund should be made on a 50/50 matching basis with non-federal funding.

7. Reimbursements for interest on borrowed capital (which is now incorporated into total acquisition cost of a laboratory or instrument) should be made a separate category in the OMB A-21 directive on indirect costs.

8. Any reorganization of the federal tax code, should recognize the importance of increased industry-university interaction. A 25 percent nonincremental tax credit should be established for industrial funding of university research and for industry-supported maintenance and servicing of university equipment. A tax deduction equal to the full market value of all industrially contributed equipment should be established

IV. THE COSTS OF ACADEMIC SCIENCE AND ENGINEERING

No nation can maintain a position of leadership in the world of today unless it develops to the full its scientific and technological resources. No government adequately meets its responsibilities unless it generously and intelligently supports and encourages the work of science in university, industry, and in its own laboratories.

President Harry S. Truman
September 6, 1945

1. Introduction

The combined efforts of government, industry and the universities have, over the years, given the United States one of the finest university systems in the world—both in scope, and in many quality measures as well. Through their tremendous diversity and accessibility, our universities have made the U.S. a world leader in science and technology. The evolution of the system has produced peaks of excellence in both public and private institutions, and across virtually all academic disciplines. Our universities continue to educate top-quality scientists and engineers, and to develop new scientific and technological insight and understanding.

In recent years, however, disputes have arisen over the costs of federally sponsored research at universities, over what those costs actually are and who should bear them. As disputes have intensified, the mechanisms for maintaining a healthy university system have broken down. For example, mistrust between universities and government agencies has led to micromanagement of the research enterprise by the agencies and the imposition of cost accounting paperwork burdens that reduce efficiency and creativity in both research and education. **The Panel believes that the time is ripe to reexamine the controversy over the costs of research and to create a system that maintains the health and excellence of our universities.**

2. The Costs of University Research

Because of the interweaving of education and research in U.S. higher education, it has never been easy to quantify the actual costs of university research. Some costs, such as those for specialized equipment, can be clearly related to research. Others, like utility costs, are more difficult since part is related to research and part to education. Accountants have divided the costs of research into two categories: direct and indirect costs. Direct costs are those attributable to specific projects—costs such as time and effort of the principal investigator, project-specific research equipment, travel expenses and so on. Indirect costs are those not easily allocatable to specific projects; examples include the lifetime costs of laboratory space and research equipment, administration, utilities, etc. The separation into these two categories, direct and indirect, is arbitrary and differs from institution to institution.

When the federal government awards a research grant or contract to a university, it agrees to reimburse that university for a set of costs attributed to that particular project. The reimbursement includes both a direct and an indirect cost. (A detailed discussion of indirect costs can be found in Appendix F.) The amount of the grant is based upon the direct costs and an additional percentage of the direct costs to cover indirect costs. The percentage, known as the Indirect Cost Reimbursement rate, or ICR rate, is agreed to by negotiations between the federal government and the university. Currently, the Departments of Health and Human Services and Defense represent the federal government in such negotiations for all of the agencies that support work in a particular university. Generally, the university will compile documentation of all costs it classifies as indirect in a given time period and attempt to determine how much of each category of indirect costs is attributable to research. The total indirect costs attributable to federally funded research is then divided by the institution's total modified direct research cost reimbursement (the "organized research base") to determine that institution's ICR rate. The indirect costs attributable to unsupported research and to other institutional activities are borne by the institution.

The Office of Management and Budget Circular A-21 attempts to define the costs of research eligible for federal reimbursement (see Appendix F). It also establishes criteria for documentation and allocation of costs, and for negotiation between federal agencies and the universities. Circular A-21 provides a framework for discussion. It has not, however, significantly reduced the controversy over the costs of research.

3. The Controversy Over Research Costs

There are three basic groups at odds in the controversy over the costs of research: faculty researchers, university administrators and government administrators. For each group, the combination of rising costs and slower growth in federal research budgets creates a different problem. To faculty researchers (and federal agencies) the problem is that indirect cost reimbursements are crowding out those for direct costs. Less and less of every research dollar is going to investigators and more and more to university administration. To university administrators, the problem is simply that reimbursements are not keeping pace with total actual university research costs. Government agencies are concerned that university research is becoming increasingly expensive at a time of increasing demands for the results of that research—talent and knowledge—and of limited federal research funding. They recognize that they will be under increasing pressure to increase the pace and scope of university research, and yet they are already in trouble funding it at its present level. They are also concerned that the research community is not, in their view, providing an adequate accounting to the taxpayers for the support received.

The controversy arises as the three groups try to reconcile their competing perspectives. Many faculty researchers, seeing their direct cost reimbursements crowded out by indirect cost reimbursements at a time when university bureaucracies often appear to them to be burgeoning, suspect that at least some indirect cost reimbursement claims are not entirely reasonable or necessary. These suspicions are reinforced by the perception that universities have few incentives to contain indirect cost reimbursements. Many government administrators, searching for ways to cut back on indirect cost reimbursements, are struck by the wide variation in ICR rates among institutions (see Table 3) and thus share with the researchers the suspicion that perhaps not all claims are reasonable and necessary. In addition, some government officials wonder whether it is even necessary or proper, particularly during a time of limited research funding, for the government to reimburse universities for all the costs they claim, even when those costs are legitimate.

It bears emphasis in any consideration of the variation of ICR rates that private and public universities really cannot be judged on a common scale. In general in the public institutions, state legislatures provide support for many aspects of infrastructure costs that in the case of the private institution become part of the federal indirect cost pool. In Table 3, for example, public institutions typically have ICR rates below 50 percent and private institutions in excess of 50 percent.

University administrators respond to faculty members and government officials with four points. First, they argue that the causes of the increases in indirect costs are real, citing as typical examples the needs for facilities and equipment, and growth in energy and library costs. The growing university bureaucracies, they contend, are a response to the proliferation of government red tape. Second, they argue that it is meaningless to compare indirect cost rates among institutions because of the variations in their accounting systems, geographical location, research orientation, age of physical plant and other differences. Third, universities argue that, despite charges to the contrary, they do have significant incentives to contain indirect costs, inasmuch as the government reimburses only that portion of indirect costs that can be attributed to government-sponsored research activities, e.g., part of library costs. Universities have always had to bear a portion of these indirect costs. Also, there is constant pressure from the research faculty to keep the ICR rate down, particularly from those faculty members whose support is administered under the NSF mechanism (see later discussion of NSF and NIH mechanisms for ICR reimbursement). Finally, the universities argue that they do not even claim many legitimate costs of federally sponsored research and that being forced to bear a greater share of those costs only diverts scarce resources from other worthwhile campus activities, many of which contribute to the overall strength of the research and education enterprise.

As university research activities grow in scope, university officials increasingly point to the fact that such costs as fund raising, the bridging of investigators or research groups between externally supported projects and the provision of seed support required to initiate entirely new research activities (in industry federal IR&D allowances provide this support) are not allowed as components of indirect costs even though they play important roles in maintaining and improving the health and vitality of the overall university research activity. These costs too must be covered by institution resources.

The controversy over direct and indirect costs focuses on two issues fundamental to any understanding between the universities and the federal government. First, which costs should be considered reasonable and necessary to the conduct of sponsored research? Second, what share of those costs should the government bear? Mutually agreed upon answers to these questions will remove a major impediment to a smoothly operating relationship between the government and the universities.

TABLE 3
INDIRECT COST REIMBURSEMENT RATES AS A PERCENT OF DIRECT COSTS FISCAL YEAR 1985

INSTITUTION	ICR RATE
Johns Hopkins	64 0
Univ of California, San Francisco	30 6
Harvard Medical School	99 0
Harvard University Areas	62 4
Yale	68 0
Stanford	69 0
Columbia	74 1
University of Washington	40 0
Univ of California, Los Angeles	43 0
University of Pennsylvania	64 0
Washington, St Louis	51 0
Yeshiva	[illegible]7 5
University of Michigan	50 0
University of Wisconsin-Madison	43 0
University of Minnesota	41 0
Duke University	50 0
Univ of California, San Diego	36 5
University of Chicago	69 0
Cornell University	63 3
Cornell University Medical College	46 0
MIT	61 5
Univ of California, Berkeley	44 0
National Average	49 3

4. Indirect Costs

There has been almost no controversy over the reasonableness and necessity of direct costs; there has been much over the reasonableness and necessity of indirect ones. This imbalance both reflects and perpetuates the misperception that direct costs are somehow inherently more legitimate than indirect ones. In fact, both are real costs of research. A possible explanation for the differing perceptions may lie in the fact that in contrast to indirect costs, direct ones are universally subject to peer review and judged qualitatively in those reviews for their reasonableness and necessity. This process is accepted as legitimate by the federal government, the universities and the investigators. The assessments made by peer review individuals and panels as to how reasonable and necessary a research budget is are generally viewed as sound and credible.

Government reviews and audits provide scrutiny of indirect costs just as peer review does of direct costs. Federal indirect costs negotiators make on-site reviews of all indirect cost proposals before the ICR rates are negotiated, and some proposals are subjected to a full audit. These reviews focus on whether the proposed costs are allowable and relevant to the performance of research and on whether the institution's apportionment methods result in an equitable allocation of costs to research programs. Because these indirect costs relate to the institution's overall operations rather than to specific research projects, such reviews cannot—and do not—make an assessment as to the reasonableness of the institution's proposed indirect cost charges and allocations.

5. The Documentation Problem

A further form the controversy assumes is over costs that are inherently difficult to quantify or justify. In an attempt to ensure that federal research dollars are being spent properly, the government has increasingly required documentation of research costs. Predictably, requirements to document costs are greatest where documentation is most difficult. In effect, the government attempts to legitimatize through paperwork research costs that are difficult, if not impossible, to justify through other methods. This does not mean that such costs are inherently unreasonable, only that it is difficult to prove otherwise. In general, the government requires documentation on costs associated with federal research as well as on some that are not. In attempting to ensure that it is reimbursing the actual agreed costs of doing federally funded research, the government has imposed layers of documentation and administration requirements upon the universities. Such inefficiency and micromanagement is a natural corollary of a research funding policy based on the procurement approach (i.e. pay for whatever is needed, as it is needed). From the faculty member's perspective the worst example of such red tape is, of course, faculty effort reporting. A workshop on effort reporting was conducted by the National Academy of Sciences; referring to faculty effort reporting, its members concluded that:

> the basic problem is that the requirements have been patterned largely after industrial practice—regular, after-the-fact reporting of time and effort expended. Such a scheme is not transferable to a university. Effort reporting forms call on faculty members to allot their time among a number of discrete functions. Most faculty effort, however, serves several ends at once and cannot be distributed rationally among discrete functions. An investigator working with a graduate student on a research project, for example, simply cannot divide such effort neatly into research and teaching.

By setting faculty, university administrators and government agencies against one another, faculty effort reporting works against the development of teamwork and of any sense of partnership in the enterprise. The reporting requirements serve to perpetuate controversy over costs that are inherently subjective and impossible to quantify, as well as creating animosity over the unproductive paperwork involved.

There are many other paperwork requirements which are equally inefficient and which serve to inhibit a healthy relationship between the universities and the government. The federal government, for example, now requires inventories of all research equipment owned by an institution, no matter how acquired, in order to compute use allowances. The government also requires exhaustive project-by-project documentation of research subcontracts to small businesses. Such requirements, even when laudable in original principle, work against the goal of efficient research.

None of the present documentation requirements promotes any greater consensus over what constitutes the reasonable and necessary costs of research. In addition to the damage they do to the university-government relationship, these requirements also obviously increase the administrative costs of federally sponsored research.

6. Micromanagement of University Research

In addition, other requirements imposed by the federal government limit the flexibility afforded researchers in the management of their federal grants or contracts. In some agencies, the period of grants is as little as two years, and many must be reviewed annually. Renewal involves preparation of detailed accounts of both past and future work, and invites concomitant scrutiny and micromanagement by peer review panels and agency program officers. Researchers are rarely permitted to carry over unexpended contract funds from one year to the next. Equipment purchases over $5,000 must be cleared through a local screening process, allegedly to prevent duplication. And perhaps most important of all, principal investigators, who are best able to judge the internal priorities of their research programs, are in some instances unable to transfer funding, for example, from other aspects of their programs to the support of graduate students and professional travel, without the explicit and time-consuming approval of agency program officers. The government, reacting in part to the controversy over the cost of research, has sought to increase accountability by imposing counterproductive regulations which impede flexibility, creativity and efficiency in university research.

The universities, in turn, have had little choice but to adopt a short-range belt-tightening view and, in consequence, have done little to either mitigate the government's distrust or increase the flexibility of the enterprise in the face of government red tape Their accounting systems are often arcane and antiquated, lending credence to the impression that they are not able to account for their costs They have seldom initiated alternative organization structures, such as cross-disciplinary centers or block grants to groups of researchers, which might increase flexibility even despite federal regulatory limitations

7. Mandatory Cost Sharing

Faced with the desire to reduce their research cost reimbursements to universities, Congress has decreed that for some agencies (e g NIH), the government should simply not bear all the costs of federally sponsored university research. Based on the concept that universities would be more determined to contain research costs if they are obliged to pay a portion of them, mandatory cost sharing was introduced as an incentive for the universities to be efficient in their management of the federal funds provided

Despite the lack of any consensus underlying the policy, the government has applied this cost-sharing principle in other areas as well In 1983, NIH indirect cost reimbursements appeared to be exceeding NIH's budgets As a short-term solution, the agency attempted to reduce its indirect cost reimbursements by 10 percent across-the-board. It made no determination that the reimbursement claims exceeded the reasonable and necessary costs, the implication was simply that NIH would not agree to pay more than 90 percent of the costs claimed. This attempt failed because of active lobbying by the research community Continuing dissatisfaction with the perceived shortcomings of the indirect cost reimbursement procedures ensure that the issue will not disappear Other, more drastic proposals, such as an indirect cost reimbursement based on a fixed 25 percent of direct costs, have recently been considered seriously by OMB

8. Indirect Cost Reimbursement

There is a final issue—the ways in which indirect costs are determined and reimbursement policies put into practice Federal agencies which sponsor university research currently employ two somewhat different methods for calculating research cost reimbursements. Both are based on OMB Circular A-21 At NIH, which funds half of the federally sponsored university research, research proposals include only the direct project costs. Review panels then consider only the direct portion of the budget; if an award is granted, the institution's current indirect cost reimbursement rate is applied automatically by the agency. In multi-year grants, should this rate rise during the term of the grant, the indirect cost reimbursement rises accordingly

At NSF, and all other major federal research agencies, reimbursement practices are similar, but their effect is in practice somewhat different At these agencies, research project budgets include the total proposed costs—the direct cost components (as in the NIH practice) plus the indirect cost reimbursement Prior to an award, the total cost is negotiated by the principal program officer on behalf of the agency and by the principal investigator on behalf of the institution Under this system, since the total is usually, but not necessarily, fixed over time, if the indirect cost rate increases, the direct cost reimbursement—those funds available to the researcher—is reduced

The practical and political differences between the two systems are noteworthy Both systems are subject to the same institution-by-institution indirect cost rates negotiated by DOD or HHS on behalf of all federal agencies. But the NIH system tends to be more closely associated with the "indirect cost problem" than does the NSF system When the GAO undertook to study the "reasonableness of rising indirect costs," it was NIH that was the focus of the study And statistics show greater growth in NIH reimbursements for indirect costs than in comparable NSF reimbursements. In 1966 when the government removed the 20 percent fixed rate on indirect costs, the ratio of indirect to total cost reimbursements was the same (20 percent) at both NIH and NSF (See Appendix G) By 1981, that ratio was 30 percent at NIH, but only 25 percent at NSF. And whereas NIH's ratio continues to grow, NSF's has remained relatively constant

Another reason why NIH has been more often associated with the "indirect cost problem" is that its system subjects fewer cost components to internal pressures within a given institution than does the NSF system In the NIH system, the researcher is concerned only with the direct costs of research, and indirect costs are the concern of a university administration negotiator and the negotiator at HHS or DOD. In the NSF system, the researcher sees each dollar of increased indirect cost recovery subtracted directly from the amount available for research, it is thus an issue between the investigator and his university's administration. In the former, the researcher argues with Washington, in the latter, with university administration colleagues. In the NIH system the pressure is on government agencies to balance rising costs against fiscal limitations, in the NSF system the pressure is on the universities In the NSF system, therefore, faculty are likely to be immediately aware of, and thus bring pressure to minimize, actual indirect costs, thereby working to keep ICR rates down

Finally, and perhaps most important of all, is the way in which the two systems affect the indirect cost controversy The NSF system is more likely than the NIH system to be accused of incomplete reimbursement, since the agencies do not adjust the total amount of a grant to absorb possible increases in the applicable ICR rate during the term of the grant Conversely, it is less likely to be accused of reimbursing for more than the reasonable and necessary costs of research, since the NSF system encourages faculty and university administrators to debate the indirect costs

Several conclusions can be drawn from this analysis First, since there has been almost no controversy over direct costs, one can conclude confidently that the peer review system is a sound, credible and effective mechanism for distinguishing reasonable and necessary costs from unreasonable and unnecessary ones. Second, because faculty pressure works to minimize indirect costs, the Panel believes that the NSF reimbursement system is preferable to the NIH one and that no obvious benefits accrue from the present dual system **We therefore recommend that all federal agencies supporting university-based research**

take steps to adopt the NSF practice for indirect cost reimbursement.

This should not become an invitation to NIH study sections to micromanage the details of project budgets. The members are not likely to be well informed about the structure of indirect costs, nor about the negotiations and audits in which each institution engages with the government. The project review staff at NIH can be appropriately educated and may then be able to guide the peer review mechanisms in ways consistent with the agency's policy. There is no reason, however, for total project costs (including indirect) to be concealed from the review process.

9. Conclusions

The attempts to define precisely the costs of research at universities have resulted in excess of paperwork that is self-defeating, and a constant source of stress between government managers, faculty, and university administrators. As an example, the mandatory cost-sharing concept has generated paperwork and consumed resources, but has resulted in nothing of value. It should be recognized that support of personnel, support of students, and the provision of an environment conducive to the conduct of research and training, in themselves constitute cost sharing. Documentation neither adds to nor subtracts from this.

Similarly, the need for faculty effort reporting results in a totally artificial separation of the multiple overlapping responsibilities of university faculty members. Since the active research effort is also a training function, since a single laboratory may have several related grants, since participation in university and departmental governance also involves administrative functions related to management of federally supported research, and, particularly, since no faculty member works as little as forty hours a week, the formal effort reporting requirements are simply administrative fictions.

These examples are perhaps the most striking, but by no means the only, manifestations of what can only be called bureaucratic accretion. Although the need for accountability which spawned these procedures is understandable, the outcome is, on balance, counterproductive to the goals of all involved. Some attempt at simplification is desperately required.

The indirect cost issue has caused similar, and perhaps even more severe, problems. In summary, indirect costs can be divided into infrastructure and administrative costs. Virtually all the controversy centers on the administrative costs and, in particular, the apparently puzzling variation in rates from institution to institution. As described in Appendix F, there is justification for this diversity. However, the effort reporting, the bureaucratic burdens, the increasing divisiveness, and the damage done to the university-government partnership that flows from the present continuing institution-by-institution negotiation of indirect costs cannot be justified.

In conclusion, the Panel strongly recommends that the federal government agree to bear its full share of the cost of university-based federally supported research. This would entail an understanding that cost sharing is inherent in the resources that universities bring to the research effort. In order to ease the stresses resulting from negotiated indirect costs, a single level for the administrative component of indirect costs should be established. In parallel, a reduction should be made in the unnecessary and overly burdensome paperwork associated with grants and contract management, elimination of the effort reporting that will follow from our recommendation for the fixing of the administrative component of the indirect cost pool will, in itself, go a long way toward reducing the friction in the government-university interface and the real level of indirect cost.

10. Recommendations

1. The federal government should bear its full share of the cost of university research it supports.

2. Reimbursements for administrative costs within the indirect cost category should be fixed at a uniform percentage of modified total direct costs. That percentage should be the mean percentage over a five-year historical period, and the adjustments should be phased in over a two-year period to allow those universities now charging more than the new fixed rate to plan for reduction. This change will eliminate much of the need for faculty effort reporting.

3. The formal requirement for cost sharing should be eliminated.

4. The paperwork burden associated with grant and contract administration should be reduced to a minimum. In the Panel view, all faculty effort reporting should be eliminated.

5. All federal agencies supporting university research should adopt the NSF practice of including the indirect costs in the project budget subject to peer review.

The Panel recognizes that some universities will face reduced indirect cost reimbursements if our recommendation concerning administrative costs is implemented. We emphasize, however, that our recommendations concerning more realistic use allowances for facilities and equipment are designed, in part, to offset such reductions. It is therefore of special importance that our recommendations be considered as an integrated package; were they to be only partially or selectively implemented, they could result in significant damage to the academic enterprise.

V. THE ENVIRONMENT FOR ACADEMIC RESEARCH AND EDUCATION

There is only one proved method of ass[illegible]ing the advancement of pure science—that of picking men of genius, backing them heavily, and leaving them to direct themselves

James Bryant Conant
Letter to The New York Times
August 13, 1945

1. Introduction

The U.S. university system is based on the fundamental conviction that the discovery of new knowledge and the education and training of new scientists and engineers are inseparable activities. Students learn to be scientists and engineers by doing science and engineering. Faculty members depend on the creativity and fresh approaches of students to challenge accepted paradigms and inject vigor and originality into the research effort. Without a sufficient flow of well prepared and motivated students entering the university system, our national scientific and technological enterprise will founder This serious national problem—characterized in *A Nation at Risk*, the report of the National Commission on Excellence in Education, as "a rising tide of mediocrity"—has been well studied elsewhere, and significant corrective measures are under way.

Central to the production of both talent and new knowledge are university faculty members; they teach students and direct research, usually simultaneously. The quality of the faculty determines how well the universities are able to respond to the Nation's demands for this talent and new knowledge. And the effectiveness of faculty members depends on the environment in which they function—what we call the academic research environment.

This environment has many components: research facilities and equipment, university administration, federal funding agencies, professional peers, industry connections, support personnel and students. In a healthy university, these components promote excellence, imagination and responsiveness in the development of both talent and new knowledge. Creating such an environment requires the best efforts of industry, government and the universities. We address a variety of issues that affect the creation of such an environment.

2. Stability of Research Support

Stability of research support means that research projects are not unexpectedly interrupted. If federal funding to an individual investigator is interrupted, it can bring the research project to an unexpected halt, seriously interrupt the progress of the graduate students involved, force reassignment of equipment and space to other projects, and place into question the professional fate of the technical staff involved. Fluctuations in federal research funding can greatly interfere with the training of graduate students. If funding for a project is interrupted or discontinued, it means inconvenience and wasted time and effort for the principal investigator But for the student, it can mean several years of graduate school wasted and for some, a comprehensive reassessment and restructuring of their entire dissertation program.

Central to the maintenance of stability is the ability of individual institutions, through fungible cash reserves, to provide flexibility of funding in the event of unexpected fluctuations in federal support. Such a capability depends both on responsible financial management by the universities and on enlightened actions by both government and industry in making it possible for the universities, already hard-pressed financially, to establish the modest reserves necessary to permit their performance of this flywheel function.

3. Optimizing the Funding Process

Most important, however, is the means by which federal funds are allocated. The U S. is unique in the extent to which responsibility for the allocation of federal dollars to scientific research is largely in the hands of the scientific community itself. This is an arrangement forged by enlightened representatives of both the federal government and the scientific community in the immediate postwar period; it has allowed this country to evolve a science and technology enterprise that is the envy of the world. The peer review system on which this arrangement is based has served the nation extremely well and must clearly be preserved, but at the same time, over the years a few difficulties have developed.

a. The Peer Review Process

In the peer review system, an investigator's research proposal is reviewed by a panel of professional peers who score the proposal, theoretically on the basis of its scientific merit. That score may reflect, to some degree, the reviewer's assessment of the investigator, but the principal emphasis has been on the proposal as such. Each agency, in general, ranks its proposals by score and awards grants in order of descending score until its budget for the year is exhausted.

The system of awarding grants and contracts on the basis of peer review is essential to our ability to maintain excellence in science. But we have noted the tendency, over the past decade, to focus more upon the specific research proposed and less upon the track record of the proposing investigator. Applied to an endeavor such as basic research—a foray into the unknown and unpredictable—this trend can be counterproductive. The skills needed by a successful and creative researcher are above all those for improvisation in the face of unexpected discoveries or disappointments. A carefully conceived proposal can never substitute for proven and sustained accomplishment—especially in the case of research of a frontier or exploratory character. And yet, proposals by established, reputable scientists continue to be rejected by peer groups and agencies on the grounds that the reviewers perceive insufficient chance of success, inadequate preparation or insufficiently precise anticipation of results. As one researcher told us,

> Unfortunately, it is not an exaggeration to say that the agencies expect a proposal to outline the anticipated discoveries. . . To require that the solutions to all problems be obvious before the research is begun discriminates strongly against innovative work.

Indeed, the peer review system has, at times, been antagonistic toward creativity, and examples exist of truly creative and revolutionary research that has been conducted in recent years only in spite of obstacles inherent in the peer review process.

In the course of our study, we have also heard testimony, which we find persuasive, that the present peer review process frequently makes it difficult for researchers to change fields. Many highly competent scientists have been discouraged from moving to possibly more productive and challenging fields by the knowledge that if they remain in their established ones they are reasonably assured of a steady flow of federal support, while if they attempt to move, they may face a much more uncertain future with new peer reviewers.

b. Structure of Grants and Contracts

A further serious problem in federal support of university research is the short duration of typical awards. Many NSF grants, for example, are made for only two years. DOD and DOE grants and contracts typically require renewal on an annual basis. As a result, investigators—and particularly young investigators—frequently spend 20 percent to 30 percent of their time and energy in sustaining the flow of their research support. Because these periods are so short, there is always the temptation on the part of peer review scientists to attempt to micro-manage the research of their colleagues, requiring modifications of proposals both at the outset and during renewal of support. And because the short periods necessitate so many reviews, the peer review system itself at times becomes overwhelmed. It is not unusual for a two-year grant request to require a year between submission and approval. If a peer review panel finds difficulties with a proposal, the funding cycle is often so far advanced that a revised proposal may be delayed until the following year. In the case of new proposals, this can simply mean a year of wasted time; in the case of renewals, it means disruption of the work already in progress.

In many cases, then, the peer review system imposes significant and time-consuming paperwork burdens. The challenge is one of retaining the truly essential quality control aspects of the peer review process while minimizing the associated bureaucracy and conservatism.

Beyond the peer review stage, there are other barriers which limit the ability of researchers to direct optimally his or her efforts. For example, the difficulty in redirecting grant and contract funds when new opportunities arise is one handicap, as is the inability to carry forward unexpended funds from one year to the next.

We particularly recommend that agencies make greater use of block grants or contracts which permit groups of interested researchers to band together in pursuing common research interests. This approach allows groups of researchers to leverage their funds in pursuing their objectives. This can also have important advantages in terms of continuity, development of highly qualified and long-term support groups, establishment of instrumentation and equipment beyond the range of any single investigator or funding instrument, maintenance of that equipment by fully qualified personnel and, perhaps most important, the freeing of younger participating scientists from the time and energy consuming bureaucracy involved in acquiring facilities, instrumentation and support at a time when their creative powers are at their peak.

4. Student Support and Education

The heart of the university research system is the parallel education of students. In view of the disproportionate leadership demands that a democratic society such as ours makes on its most able citizens, it is in the national interest that these individuals be identified and adequately supported at an early point in their careers so that they can develop their skills to the fullest. No nation can long afford to waste even a small fraction of its most able youth. It is important to recognize that many of these individuals are ineligible for the support, under current programs, that would enable them to attend the institutions of their choice.

It is important to emphasize that the most able students in mathematics, engineering, and the natural sciences be enabled to develop their intellectual potential and creativity. We are confident that this is in the national interest; it is the most effective investment that any nation can make in its future. It is an essential contribution to ensuring that there is an appropriate pool of well-educated, interested, and dedicated young people from which our graduate schools can draw.

a. Undergraduate Scholarships

We emphasize our recommendation that this support to undergraduate students be provided through programs of competitive merit-based scholarships. All these at the undergraduate level should be portable in the sense that once awarded, the successful student should be entirely free to hold the scholarship at the institution of his or her choice. In addition to supporting our most able youth, such a program has the great advantage of providing a powerful incentive to the receiving colleges or universities to evolve education programs of particular interest and attraction to the most able students.

We recommend that as a national goal 1 percent of the most able undergraduate students in mathematics, engineering and the natural sciences entering colleges and universities each year be supported under these programs. In 1983, some 196,923 students received their baccalaureate degrees in engineering, mathematics and natural science. If we take this as a basis for estimation and assume that 1 percent of the entering students receive four-year scholarship support at the level of $15,000 per year, the annual program cost is roughly $120 million. We consider this to be perhaps the single wisest investment that we, as a Nation, could make.

It is sobering to recognize, too, that statistics on the student populations already in the precollege pipeline show that in the early 1990's the annual number of baccalaureate degrees awarded will be close to 150,000 rather than approximately 200,000 as in 1983. These are the data that underlie current NSF projections of very serious shortages of engineers and scientists in the 1990's.

It must also be emphasized that the merit-based scholarship programs that we recommend are certainly not intended in any way to replace the current need-based programs that have given access to higher education to a wide spectrum of students to whom it would otherwise have been denied—as well as making our universities and colleges more interesting and effective institutions.

b. Graduate Fellowships

At the graduate level, a portion of the awards should be reserved for fellowships for study at designated institutions in order to take advantage of special programs or facilities or in order to emphasize areas where special national needs may become evident.

As shown in Figure 9, the percentage of foreign students receiving doctorates in a number of fields—but most especially engineering—has been increasing in striking fashion in recent years. It must be emphasized, however, that this trend does not reflect any greatly increased flow of foreign students into our graduate schools but rather a marked decrease in the number of U.S. students who, in the face of other opportunities, are choosing to continue their education at the graduate level.

The current shortage of U.S. graduate students in engineering, mathematics, and physical sciences is being offset partially by foreign students in U.S. universities. The trends are a very persuasive endorsement of the quality of U.S. graduate education in engineering, mathematics, and the natural sciences as viewed from other countries, but they also indicate the need to provide incentives for U.S. students to continue their education in these critical areas.

5. The Universities and Industry

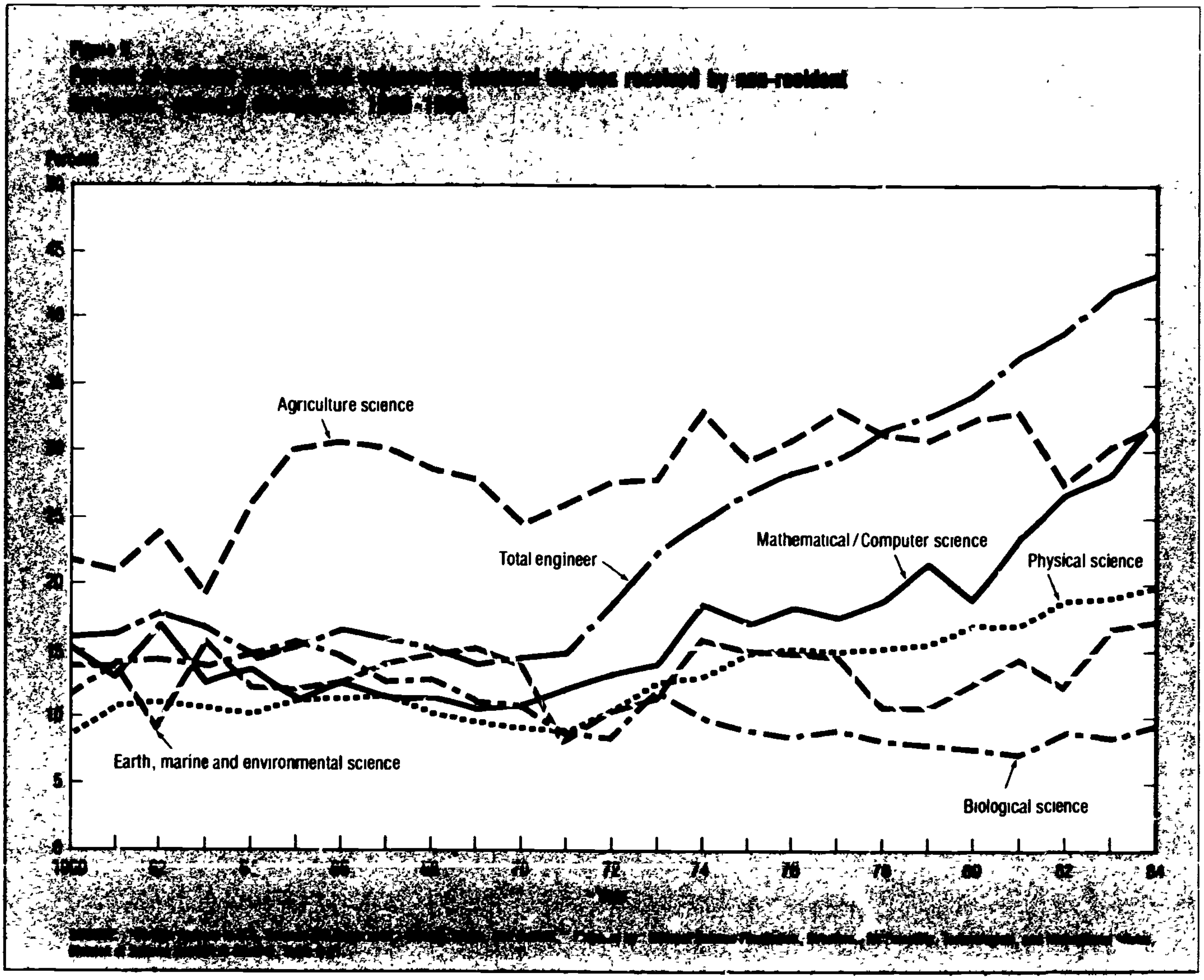
Because industry is the ultimate customer of a large fraction of the scientific and technical talent and the new knowledge produced by the universities, industry's wisdom and influence, quite apart from its financial support, are essential inputs to the university research environment. In recent years, substantial progress has been made toward rebuilding the industry-university bridges that were largely destroyed during the period of rapid growth in federal support of university activities in the 1950's and 1960's; much remains to be accomplished in this vital interface, if a true industry-university partnership is to be established in this country.

As noted in Chapter III, industrial involvement with universities is increasing through a variety of mechanisms. In addition to these varied forms of research interactions, it must be recognized that the prime motivation for overall industry support of the health and activity of U.S. universities is the continuing demand for trained scientists, engineers and other graduates. The technological revolution not only makes heavy demands for new young scientists, mathematicians, and engineers in the marketplace, but also focuses increasing attention on the crucial need for effective continuing education.

Not too long ago it was widely assumed that the educational phase of one's life was over after the completion of a formal university training and that it was time to move on to the real world, applying that education. But the increasingly rapid pace of technological change has made such a view totally unacceptable—if indeed, it ever was acceptable. Obsolescence of engineering and scientific skills is becoming ever more rapid, and in their own self-interest, industries must work with universities to develop and support new mechanisms and programs whereby university resources of faculties and facilities can be made more available to older scientists and engineers who recognize the necessity of renewing and modernizing their expertise or who may wish to make a major change in their career path. Universities and industries should work together to provide effective life-long educational opportunities for employees and technical people generally.

As noted earlier in this report, the current U.S. competitive position in defense, trade, and health is strongly coupled to earlier investments in science and technology. We are now being challenged to remain competitive in those very areas of science and technology where our preeminence was once unquestioned. To respond to this challenge we must reestablish those links between industrial innovation and academic science that were in the past the catalysts of U.S. industrial technologies.

And this must be done with the recognition that the problems to be addressed have burst the conventional disciplinary boundaries. The basic research that will be necessary to fuel our economy in the future will require interactions across disciplines and with the active collaboration of many groups having different perspectives and training.



It is our conviction that the multidisciplinary centers (discussed earlier) based on these premises will allow a flexible response to new opportunities, give industry a window into the campus environment, and will pay back the public investment manyfold. Such programs offer a student who has a firm grounding in one of the established disciplines at the undergraduate level an opportunity to contribute his expertise as an effective partner in a multidisciplinary program at the graduate level that truly draws on the insights and intellectual resources of all the relevant disciplines. Such centers can provide a focus for faculty members who straddle traditional departmental boundaries and for whom universities often find it difficult to establish long-term positions.

6. The Universities and the Federal Laboratories

Increased interaction between the federal laboratories and the universities should be encouraged. The Panel fully supports the recommendation in the White House Science Council Report on Federal Laboratories that these laboratories should encourage much more access to their facilities by both universities and industry. Exchange programs that provide opportunities for faculty and graduate students to work in the laboratories and for laboratory scientists to teach in the universities and colleges should be enhanced. The value of increased involvement of university scientists and administrators as advisors to laboratory programs was also noted in the Energy Research Advisory Board Report on the Relationships between DOE and the Universities. The potential for existing federal laboratories to play a complementary role to the universities in both research and training should be further developed.

7. Role of State Governments

Like industry and the federal laboratories, communities benefit substantially from being located near strong universities. Silicon Valley in California, Route 128 in Massachusetts, Research Triangle Park in North Carolina, and similar developments in Austin, Texas, are well-known examples. State governments have a responsibility to help shape and develop local universities to meet regional needs and characteristics. Particularly with respect to state universities but also for private universities, states can have a profound effect on the quality of institutions by augmenting federal research programs in areas of particular regional interest (i e , agriculture, seismology, metallurgy) by providing infrastructure support and unrestricted grants to institutions, to groups of researchers or to individual faculty members and by becoming actively involved in the education process Perhaps most significant, the state governments can work with local universities and industry to improve pre-college education in science and mathematics, creating ripple effects throughout the entire education system.

8. Conclusions

The combination and balance of factors that create an effective environment for academic research and training are complex and largely undefinable. The Panel has attempted to identify several issues that have a significant effect on the way research and training is conducted at universities, and where beneficial changes can be made.

It is clear to us that the short duration of grants at many federal agencies provides paperwork barriers and fiscal uncertainty for the investigator that far outweighs any advantage to be gained by more frequent monitoring of research progress.

An important initiative that we recommend to increase the effectiveness of the academic research environment is the increase in duration of most federal grants to at least three and preferably five years. This would increase not only stability but also effectiveness in reducing the number of renewals and the amount of reporting paperwork required in a given period of time During the past year, NIH has already taken important steps to lengthen the periods of their grant commitments. We applaud this initiative and encourage other agencies to follow suit.

A related issue is the liberalization of policy so that investigators can make the most effective use of their funds To increase stability and flexibility in the use of research funds, we recommend that successful investigators should be allowed to use 10 percent of their grant or contract funding on a discretionary basis; further, they should be allowed to carry forward unexpended funds in their grants or contracts from one fiscal year to the next.

As a final point in this area, we recommend that agencies should make much greater use of block grants or contracts which permit groups of interested researchers to band together in pursuing common research interests

We would encourage the peer review group to focus less on the predictability of success implied in a proposal, and more on the track record of the investigator

Together with research, the major mission of the university is the training of young minds. It is the view of the Panel that a vital element of national well-being depends on the opportunities provided to its most able citizens, regardless of economic or social class. Perhaps the most important guarantee that these opportunities will exist, is appropriate education and training

We recommend, therefore, the establishment of substantial programs of merit-based, portable, federally supported scholarships and fellowships in mathematics, engineering, and the natural sciences at the undergraduate level We further recommend that parallel programs in industry be established at the initiative of individual companies. It is essential that, at the undergraduate level, all these scholarships should be portable in the sense that once awarded, the student be allowed complete freedom to select the university or college in which the award is to be held

We recommend that the Nation should accept as a goal the provision of merit-based support for the most able 1 percent of our students in mathematics, engineering, and the natural sciences entering colleges or universities each year We are convinced that this will represent the most effective investment that this Nation can make in its future. Substantial programs of multiyear merit-based fellowships, both federal and industrial, should also be established in science, mathematics, and engineering at the graduate level Reflecting broad national needs, the field distribution of these fellowships likely would change over time. At the graduate level, we recognize that it will be desirable to have a substantial fraction of the awards nonportable in the sense that they are attached to a particular institution, facility or program to reflect perceived national needs.

In order to insure that students can be sufficiently trained to cope with the changing boundaries of research, we recommend that more emphasis in universities be placed on the development of interdisciplinary programs at the graduate and postdoctoral level Universities offer a unique environment where not only scientific and technological expertise but also that from the social, behavioral and economic sciences as well as the humanities can be brought to bear on problems of major importance

We note that industries and universities have a common need and responsibility to develop attractive continuing education mechanisms and programs for engineers and scientists that are matched to contemporary industrial requirements and to modern science and technology

9. Recommendations

1 Federal agencies should work toward an average research grant or contract duration at universities for at least three, and preferably five, years

2 Investigators should be free to use up to 10 percent of their grant or contract support on a fully discretionary basis and should be permitted to carry unexpended funds forward from one fiscal year to the next

3 Federal agencies should make much greater use of block grants or contracts in support of groups of investigators having shared research interests

4 For greater flexibility, to facilitate changes in an investigator's field of research, and to support high-risk research, federal support agencies should, except in the cases of young investigators, place substantially more emphasis upon the research history of the investigator and less on the proposed research project in making awards

5 A substantial program of merit-based, portable scholarships should be established by the federal government at the undergraduate level Parallel programs should be established by all industries having significant dependence upon university research and education The national goal should be for the most able 1 percent of the undergraduate

students in mathematics, engineering, and the natural sciences entering colleges or universities each year to be supported under these programs This program is recommended as an addition to, not a substitution for, existing need-based federal assistance programs

6 Substantial programs of multi-year merit-based fellowships, both federal and industrial, should be established in science, mathematics, and engineering at the graduate level Reflecting national needs, the field distribution of these fellowships would be expected to change over time

7 Universities should encourage interdisciplinary activities at the graduate level while retaining the essential quality control function now played by the traditional disciplinary departments

8 Industries and universities should develop attractive continuing education programs for engineers and scientists that are matched to contemporary industrial requirements and to modern science and technology

VI. Summary

For most of this country's history, basic research was largely neglected, and came predominately from Europe. Federal involvement in universities was primarily in applied areas such as agriculture and engineering. Industry also had limited interaction with universities, and again essentially in applied fields. For the past 40 years, the major elements in the evolution of university-based research has been the relative weakening of the university-industry connection and the strengthening of the university-federal government interaction. (Note that a three-way "partnership" has never had more than a transient and limited existence.) In parallel with these changes has come a growing recognition of the importance of basic research in serving the needs of society, and of the importance of the universities in this endeavor.

The federal government's relationship with the universities has always been based on the premise that university activities are fundamental to meeting society's needs. Over a century ago, the Nation's dependence upon the agricultural economy stimulated establishment of the land-grant colleges, whose research and training helped make American farmers the most productive on earth. Today, we depend on technology for our competitive edge in virtually every area of our economy. Our investments in university education and research, and thus in new scientific knowledge and talent, are therefore even more important. To carry out this mission, it is essential that the major participants in the research enterprise, government, industry, and universities, clearly define their roles and responsibilities in the partnership.

It must be recognized, however, that university-based research has, in the modern era, been 70 percent supported by federal funds and that more than 60 percent of the basic research performed in this country is conducted at universities. The long-range nature of basic research, and the absence of any predictable payoff, effectively precludes significant investment from industry. Furthermore, the scope of university-based research is far too great to be supported through internal resources alone. Consequently, it is the federal contribution that will determine the rate of growth of the system. Perhaps even more important than the level of funding, however, is the need for stability and predictability of scope and support from federal funding. They are essential to the effective use of financial and human resources. In the past, such stability has been sadly lacking. In its absence, important opportunities have been lost, resources have been used in less than optimum fashion, and, most serious of all, some of the brightest young minds have been lost to science and technology.

The interaction of industry with the universities is essential to provide an effective exploitation of the research base. This partnership is critical to our national well-being in an increasingly competitive world marketplace. Particularly important is the assistance industry can give in understanding the translation of basic research to technology development. As noted earlier, the nature of these interactions are as important as the direct financial contributions which industry may make to the support of research.

The Panel has attempted to identify some specific problems, and has made specific recommendations that bear on the health of the universities. **Independent of the scenarios that the Panel has considered, one clear fact emerges. Within the context of probable future growth, hard choices lie ahead for universities. It will not be possible to accomplish all the things that would be in the national interest in the near future; it may well be impossible to accomplish all of them even in the long term.** It is the responsibility of each university to make the difficult trade-offs among faculties, facilities and programs necessary to maintain its institutional health and vitality within whatever level of external support it may find itself constrained to operate. It is equally the responsibility of all of the participants in the R&D enterprise mutually to establish the goals of federal funding—particularly the questions of stability and growth, enhancement and expansion. Only then can the details be defined in a rational manner.

VII. APPENDICES

A. Charge to the Pancl

B. Activities of the Panel

C. Witnesses Who Appeared Before the Panel

D. Panel Questionnaires

E. Correspondents Who Provided Input to the Panel

F. Indirect Costs

G. Summary History of Indirect C

H. Nume-ical Data

I. Selected Bibliography

APPENDIX A

THE WHITE HOUSE

WASHINGTON

May 3, 1984

Dear Sol:

As you know, our nation's ability to compete successfully both in the military and industrial arenas will depend a great deal on the continued creation of knowledge and an adequate supply of scientific and technical talent. The support of basic research and the production of such talent are major objectives of the Administration's science and technology policy. The continuing health of our nation's universities is fundamental to this policy. Although our universities and colleges are now the best in the world, I am concerned that lack of agreement on a number of long-standing problems could affect their health and vitality. These problems have been documented in numerous recent studies. They directly affect the ability of the universities to attract and retain the best minds both to do research, and to teach and learn, in science, engineering and medicine.

I would appreciate it if the WHSC would examine and make necessary recommendations for revising the principles underlying the relationships between the Federal government and the universities, especially as they affect the U.S. ability to create the scientific and technical talent and to conduct the research needed to sustain America's leadership in industry and defense. The Council should provide a tautly reasoned policy statement, which would serve to guide Federal actions with respect to universities and colleges.

My office will coordinate the necessary staff support, resources and administrative arrangements for your effort.

Yours truly,

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Science Advisor to the President

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APPENDIX B

ACTIVITIES OF THE WHSC PANEL ON THE HEALTH OF U.S. COLLEGES AND UNIVERSITIES

The Panel was established by the White House Science Council, at the request of Dr George A Keyworth, former Science Advisor to the President

Its initial organizational meeting was held in Washington on May 17, 1984 Subsequently, the Panel held eight additional one-day and two two-day meetings Over the period since May of 1984, a substantial number of working group meetings have been held in Washington, New York and New Haven in order to prepare material for discussion at the plenary sessions held on June 19, August 6-7, September 19-20, October 25, November 29 of 1984, and January 11, February 8, June 7, June 27 and September 28, 1985

During the meeting on September 19, 1984, the Panel heard from a number of representatives of the academic and scientific communities (see Appendix C), and during that on June 7, 1985, from representatives of the Department of Health and Human Services. During working group sessions, members of the Panel and OSTP staff met with representatives of the Department of Defense, National Science Foundation, Office of Management and Budget, National Institutes of Health, Association of American Universities, National Research Council and the Council on Governmental Relations

In order to obtain input from as broad a spectrum of opinion and experience as possible, the Panel prepared questionnaires (see Appendix D) which were sent to a sample of university presidents, academic principal investigators, academic administrators, industrial chief executive officers, foundation executives and executives of academic associations

The list of those who responded to these questionnaires or who volunteered input to the Panel is provided in Appendix E The insight provided by these correspondents has been of great assistance

A penultimate draft of this Report was circulated to the Panel members for comment in August of 1985, to members of the White House Science Council and to a very limited number of senior federal administrators who generously agreed to receive the draft on a privileged basis and provide us with their critical comment The comments received from all of these readers have been most helpful to the Panel

On September 26, 1985, the Panel held its final meeting at which time the content of the Report was finalized for transmission to the White House Science Council

Dr. Bernadine Healy, Deputy Director of the Office of Science and Technology Policy, has served as Executive Secretary of the Panel She and Dr George Keyworth, Director of OSTP, have been active participants in the Panel activities. We have been most ably supported by Mary Gant and other members of the OSTP staff The warm thanks of the Panel goes to all of them.

APPENDIX C

WITNESSES APPEARING BEFORE THE PANEL

September 19, 1984

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Gary Talesnik
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Office of Procurement and Assistance, Financial Management
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APPENDIX D1

QUESTIONS SENT TO UNIVERSITY PRESIDENTS

1. What do you believe to be the major problems, if any, in training new scientific and engineering talent in our universities and colleges? Any solutions?

2. Do you perceive instabilities in the current partnership of government-university sponsored research? If so, what are they?

3. Are there federal policies regarding government research funding that you find unduly burdensome? Any suggestions for change?

4. What in your view is the best way to deal with the rising indirect cost rate for sponsored research? Are there ways that the departmental and sponsored project administration costs, which comprise close to 40 percent of total indirect cost reimbursements, can be reduced?

5. How are you affected by the federal requirement for cost sharing and its documentation? How best should the university and government share the costs of research?

6. What are the risks and benefits of university-industry collaboration with regard to financial interaction or exchange of human capital?

7. What impediments to fruitful research are most often mentioned by researchers? What changes, if any, might alleviate these impediments?

8. What is your assessment of your university's facilities (buildings and equipment) for science and technology? If you have problems with facilities, what aspects, if any, appear to defy resolution without federal government involvement?

9. What steps, if any, could the federal government take to improve the quality of science and engineering education at non-research (i.e., primarily undergraduate) institutions?

10. Do foreign students comprise a substantial portion of your science and technology student body? What advantages and disadvantages do they present?

11. Do you set priorities among areas of science in allocating research resources within your university? If so how?

12. Are there specific interactions between your institution and the federal R&D agencies that you see as posing difficulties or you would like changed? Do you feel you have a voice within those agencies on issues of funding mechanisms, peer review, etc?

APPENDIX D2

QUESTIONS SENT TO FOUNDATIONS

1 From your perspective, what are the major strengths and weaknesses in the U S university system with respect to the training of new scientific talent?

2 Because of escalating costs, problems with facilities, equipment, and faculty shortages in some disciplines, there is concern about the ability of U S universities to carry out their research and educational missions in science. In general, what responsibility does the federal government have, if any, to correct the situation?

3 The federal government supports about 66 percent of U S basic research From your perspective, is the present program of support properly distributed among the various areas of science to meet the needs of today's industries?

4. Almost half of the federal funding for basic research goes to roughly 25 top U S research universities Should the government broaden the support and increase the number of top research universities? If so, how?

5 What role, if any, should the federal government assume in providing new or replacement capital for universities in which significant numbers of scientists and engineers are trained? What is industry's role?

6 What are the risks and benefits of industry and university collaboration either with regard to financial interaction or exchange of human capital? Should the government seek to increase research interactions between industry and the universities and, if so, 1) how important is this task and 2) what mechanisms should be employed to accomplish it?

7 Could industry benefit from greater involvement with universities? If so, what factors limit its interaction?

8 What should be the federal policy with regard to admission of foreign students in science and engineering at U S universities?

9 How actively does your organization support academic institutions? How many resources, human or fiscal, are involved?

10 Do you think industry is able to attract the number and quality of technical talent to meet its needs?

APPENDIX D3

QUESTIONS SENT TO INDUSTRIAL CHIEF EXECUTIVE OFFICERS

1 From your perspective, what are the major strengths and weaknesses in the U S university system with respect to the training of new scientific talent?

2 Because of escalating costs, problems with facilities, equipment, and faculty shortages in some disciplines, there is concern about the ability of U S universities to carry out their research and educational missions in science In general, what responsibility does the federal government have, if any, to correct the situation?

3 The federal government supports about 66 percent of U S basic research From your perspective, is the present program of support properly distributed among the various areas of science to meet the needs of today's employers, especially industry?

4 Almost half of the federal funding for basic research goes to roughly 25 top U S research universities Should the government broaden the support and increase the number of top research universities? If so, how?

5 What role, if any, should the federal government assume in providing new or replacement capital for universities in which significant numbers of scientists and engineers are trained? What is industry's role?

6 What are the risks and benefits of industry and university collaboration either with regard to financial interaction or exchange of human capital? Should the government seek to increase research interactions between industry and the universities and, if so, 1) how important is this task and 2) what mechanisms should be employed to accomplish it?

7 Could your firm benefit from greater involvement with universities? If so, what factors limit your interaction?

8 What should be the federal policy with regard to admission of foreign students in science and engineering at U S universities?

9 How actively does your organization support academic institutions? How many resources, human or fiscal, are involved?

10 Is your institution able to attract the number and quality of technical talent to meet your needs? Is this issue a concern in your corporate planning?

APPENDIX D4

QUESTIONS SENT TO PRINCIPAL INVESTIGATORS

1. What do you believe to be the major problems, if any, in training new scientific talent in our universities and colleges? Any solutions?

2. What changes do you think would make a career in university research and teaching more attractive to young PhD's?

3. Are there federal policies regarding government research funding which you find unduly burdensome? Any suggestions for change?

4. What in your view is the best way to deal with the rising indirect cost rate for sponsored research? Are there ways that the departmental and sponsored project administration costs, which comprise close to 40 percent, can be reduced?

5. Should the federal government allocate more funds to institutional or block grants, or to larger multicomponent specialized center grants? What do you view as the relative advantages and disadvantages of individual, block and center funding?

6. Do you have specific concerns about or comments on federal agency grant application mechanisms, funding time periods, the review cycles, or appeals process?

7. Do you see problems with the existing peer review mechanism? How should methodology, quality of ideas, and track record of the investigator be weighed in evaluating a proposal?

8. What is your assessment of your university's facilities (buildings and equipment) for science and technology? If there are problems with facilities, what aspects, if any, appear to defy resolution without federal government involvement?

9. Do you have direct experience with industry supported research? What have been the benefits and costs of such research?

10. Do you have concerns about the number of foreign graduate students in science and engineering? What advantages and disadvantages do they present?

APPENDIX E

CORRESPONDENTS WHO PROVIDED INPUT TO THE PANEL

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APPENDIX F

Indirect Costs

1. The Components of the Indirect Cost Pool

To better understand the controversy, it is helpful to disaggregate the indirect cost category into its component cost pools. Under the present framework established in OMB Circular A-21, indirect costs are divided into the following pools

Indirect Cost Pool	Average Indirect Cost Reimbursements in 1984
(1) Operation and Maintenance (utilities, janitorial services routine maintenance, etc.)	28%
(2) Use Charges for Buildings and Equipment (or depreciation of institutional assets)	10%
(3) Libraries (books and materials, salaries, expenses and fringe benefits of librarians and library staffs)	4%
(4) Student Administration and Services (costs of registrar, deans of students, student advisors, health services, etc.)	1%
(5) General Administration (salaries, expenses and fringe benefits of university officials and university-wide offices, such as personnel, accounting and payroll)	15%
(6) Sponsored Projects Administration (salaries, expenses and fringe benefits of administrators and staff in offices set up to administer sponsored research programs)	7%
(7) Departmental Administration (salaries, expenses and fringe benefits of personnel [e g chairmen, secretaries and faculty] in academic departments and divisions, and organized research units attributable to administration activities)	33%

In essence, these seven pools are actually subdivisions of two types of costs: the first three may be considered infrastructure costs and together they currently amount to approximately 23 percent of costs, on average The second four are administrative costs, and together they amount to about 26 percent of direct costs, on average Together, university indirect costs now constitute, on average, almost one third of total research costs, or half of direct costs

2. Infrastructure Costs

There is no universally applicable rule of thumb for determining what are reasonable and necessary costs of infrastructure. Institutions have different expenses according to their age, geographic location, disciplinary specialities, etc But determining the infrastructure costs at a single given institution is not especially mysterious. The costs are relatively easy to document, and the types of costs do not vary significantly from institution to institution The controversy over the costs of facilities and equipment, however, does not involve uncertainty as to how they are determined, rather the uncertainty is over whether, or to what extent, they are recognized by all parties as legitimate, reasonable and necessary costs of research In the last decade and a half, universities and government have been unable to agree on these matters

In fact, the costs of research facilities and equipment are reasonable and necessary costs of research Modern research is impossible without modern laboratories, libraries, instruments and computers, and the health of the university system is fundamentally dependent upon the condition of these items in the universities. In order to fund the capital investments necessary for the establishment of such facilities, many universities have undertaken substantial indebtedness through direct borrowing or the issuing of bonds. We have recommended substantial changes in the regulations governing use allowances for facilities and equipment in order to more nearly reflect the actual situation in the universities

3. Administrative Costs

The controversy over administrative costs is quite simply over which costs should be considered reasonable and necessary Central to the controversy is the matter of administrative costs At a time when indirect cost reimbursement rates are rising, many researchers suspect that some of the costs claimed for departmental and sponsored projects administration activities are, in fact neither reasonable nor necessary Departmental administration costs are regarded dubiously because they are computed substantially on the basis of faculty effort reporting, sponsored project administration costs are also based in part on effort reports and—in the view of many researchers—reflect a haven for unproductive bureaucrats. By and large, the universities have defended ICR rate increases by pointing to increases in infrastructure cost pools, while researchers and government representatives have complained about ICR rate increases by pointing to administrative cost pools.

In 1983, in its study of the costs of federally funded R&D, the President's Private Sector Survey on Cost Control—the Grace Commission—issued its *Task Force Report on Research and Development*. With respect to administrative costs, the report concludes.

> The administrative components of the indirect cost rate (departmental administration, general and administration, and sponsored project administration) are the most difficult components to establish on the basis of documented, objective evidence and further attempts to reach a compromise on acceptable forms of docu-

mentation will only create mor friction and frustration Instead fixed rates should be negotiated and the ongoing requirements for documentation of actual rates should be eliminated

It further recommends.

The cognizant agencies should negotiate indirect cost rates that include a fixed rate for the administrative components and relieve the universities of the main portion of the burden associated with effort reporting

A report released in March 1984 by the General Accounting Office (GAO) entitled, *Assuring Reasonableness of Rising Indirect Costs on NIH Research Grants—A Difficult Problem*, states

> Departmental administration expenses are subjective and not easily verified (p iv), [and notes that such costs] will undoubtedly be the source of continuing controversy. (p vii)

The Panel finds itself in full agreement with these findings and with the Grace Commission recommendation

Government representatives, researchers and university administrators all described departmental administration costs in terms similar to those used by the Grace Commission and by GAO Departmental administration con[illegible]ises some 30-35 percent of indirect cost reimbursements (60-70 percent of administrative cost reimbursements), the largest fraction of any indirect cost pool and twice as large a fraction as the next largest administrative pool—general administration While university administrators will generally acknowledge that faculty effort reporting is nonsensical and that departmental administration expenses are thus difficult to justify, they contend, with some argument from the government and the researchers, that reimbursements for the three remaining cost pools (general administration, sponsored projects administration and student services) reflect reasonable and necessary administrative costs

The next most controversial administrative pool after departmental administration, sponsored project administration, accounts for about 8 percent of indirect cost reimbursement and covers the administrative costs associated with the actual federal grant and contract process It has two components The first is the cost of operating separate organizational units established specifically to administer federal grants and contracts, the second covers administrative activities outside of the separate units which benefit federally sponsored programs exclusively This latter component is based, to a large extent, on faculty effort reporting and is thus subject to the same controversy as departmental administration.

Reimbursement for student services administration is not large enough at most universities to be significant

Finally, there is the general administration category, which includes the costs of the central administration of the institutions involved and various other miscellaneous administrative items Although it currently represents about 15 percent of indirect reimbursements, the general administration category has not been subject to significant controversy. Furthermore, it has not shown the sort of growth recently characteristic of the other administrative pools

4. Diversity and Variation in Administrative Rates

Clearly, one of the strengths of the U S higher education system is the diversity that has allowed the system to develop centers of excellence, institutions with unique capabilities and a degree of accessibility unmatched in the world

The universities contend that the present indirect cost reimbursement mechanism, by basing reimbursements on documented costs, is flexible enough to reflect and help maintain this diversity The present cost allocation mechanism, however, stimulates confusion over the manner in which already controversial costs are reimbursed Similar administrative costs can be charged to a number of different cost pools—direct or indirect, departmental administration or sponsored projects administration, etc. A paper prepared for the Panel by the Council on Governmental Relations (COGR), an association of university financial officers lists, by example, a number of costs that are classified differently at different institutions Many of the differences in classification reflect differences in internal organization As the paper notes,

> Essentially, the variety of methods used to group and allocate costs was basically the result of the variety of organizational structure

These structures in turn reflect variation in an enormous number of individual institutional characteristics

One of the questions the COGR analysis sought to answer was why many seemingly similar institutions have such dissimilar administrative cost rates in both the aggregate and within specific component pools. It concluded that there are four principal reasons for differences in aggregate administrative cost rates from institution to institution.

1 Similar administrative costs may be charged indirectly at one university and directly at another
2 The same costs may be regarded as administrative costs at one university and as operational or plant costs at another (more likely, as one administrative pool at one university, anot[illegible] at another)
3 Excluding costs from the aggregate direct category can cause the same amount of administrative costs to be reflected in a different ICR rate
4 How vigorously an institution accounts for costs, and negotiates reimbursements, may affect the amount charged to administrative pools

The first three of these reasons, according to the COGR report,

> result in shifting of costs among various indirect and direct cost categories, the remaining reason results in modifications in the total amount of costs claimed

The primary reason why the total administrative costs charged differ from institution to institution is simply that institutions differ in the degree of vigor they apply to accounting for, and charging for those costs The Panel concludes that there does not appear to be as much variation in actual administrative costs as the diversity in the system might suggest

5. The GAO Recommendation

To resolve some of the current controversy the 1984 GAO report recommends that OMB amend Circular A-21 to [illegible] reimbursements for departmental administration as a percentage of direct reimbursements, replacing the "cost reimbursement" method now used. The reimbursement, suggests the GAO report, could vary on an institution-by-institution basis, depending on their individual circumstances, but should not rely on effort reporting to represent those circumstances. The reimbursement should represent a reasonable amount needed for effective research administration at the departmental level of each institution. The GAO report followed a similar proposal by HHS contained in a 1983 report to Congress.

6. The Stanford and Yale Agreements

In the meantime, two universities, Stanford and Yale, have undertaken to deal with the problem individually and ease their paperwork burdens, reduce their administrative costs and eliminate some of the adversity created by the ongoing indirect cost controversy. Each university negotiated a fixed rate for departmental administration in exchange for reducing effort reporting requirements. Both agreements have finite durations. Stanford's must be renegotiated after five years, Yale's after four. Both institutions, according to the NAS Workshop on Effort Reporting in A-21 made financial concessions in their agreements, but did so on the stated grounds that the financial loss was outweighed by the intangible gains in the morale and spirit among researchers, and a greater collegiality among researchers and administrators.

APPENDIX G

A Summary History of Indirect Costs

1950-1965

Cost principles for indirect cost reimbursement formally worked out, and published in a Bureau of the Budget Circular A-21 in 1958 The Department of Health, Education and Welfare set a fixed upper limit on indirect cost recovery for grants This was 8 percent initially, changed to 15 percent in 1958, and 20 percent in 1963

1966

Indirect cost ceiling removed Cost-sharing required by law in the Department of Health, Education and Welfare Appropriations Act

1975-1979

Sixth revision of Circular A-21 Revised requirements for effort reporting and standard basis for distributing costs among projects

1982

Seventh revision of Circular A-21 Effort reporting requirements eased, and interest expense made allowable in specific circumstances

APPENDIX H

NUMERICAL DATA FOR FIGURE 1 NOT AVAILABLE.

NUMERICAL DATA FOR FIGURE 2

National R&D Funding Trends: 1953-1984

(Constant 1972 dollars in billions)

Year	Total R&D	Federal R&D	Nonfederal R&D
1953	8 6	4 6	4 0
1954	9 4	5 2	4 2
1955	10 1	5 7	4 4
1956	13 3	7 7	5 6
1957	15 0	9 4	5 6
1958	16 2	10 2	6 0
1959	18 3	11 9	6 4
1960	19 6	12 7	6 9
1961	20 6	13 3	7 3
1962	21 7	14 0	7 7
1963	23 7	15 6	8 1
1964	25 9	17 2	8 7
1965	26 9	17 4	9 5
1966	28 4	18 2	10 2
1967	29 2	18 2	11 0
1968	29 8	18 1	11 7
1969	29 6	17 2	12 4
1970	28 6	16 3	12 3
1971	27 8	15 6	12 2
1972	28 5	15 8	12 7
1973	29 1	15 6	13 5
1974	28 8	14 8	14 0
1975	28 2	14 5	13 7
1976	29 5	15 1	14 4
1977	30 5	15 4	15 1
1978	32 0	15 9	16 1
1979	33 6	16 4	17 2
1980	35 1	16 5	18 6
1981	36 7	17 1	19 6
1982	38 2	17 5	20 7
1983	40 1	18 6	21 5
1984	42 5	19 9	22 9

Source National Science Foundation *National Patterns of Science and Technology Resources 1984*

NUMERICAL DATA FOR FIGURE 3

FEDERAL EXPENDITURES ON UNIVERSITY RESEARCH: 1953-1984

(Constant 1972 dollars in millions)

Year	All Research	Basic Research	Applied Research	Development
1953	234	124	96 80	13 00
1954	268	151	113 60	16 70
1955	277	169	95 10	13 10
1956	339	207	108 10	23 80
1957	352	238	95 30	19 00
1958	384	270	96 00	18 10
1959	453	335	99 20	19 20
1960	590	435	129 00	26 20
1961	722	551	141 50	28 80
1962	869	682	154 00	32 60
1963	1062	852	178 70	30 70
1964	1260	1055	175 00	30 00
1965	1444	1182	212 00	49 70
1966	1643	1313	252 70	76 80
1967	1783	1422	280 90	79 70
1968	1905	1515	307 00	83 00
1969	1845	1475	283 00	86 50
1970	1804	1419	293 30	91 90
1971	1795	1405	304 10	86 40
1972	1795	1420	320 00	55 00
1973	1877	1375	420 00	63 70
1974	1766	1323	380 60	61 60
1975	1819	1347	410 20	62 00
1976	1893	1391	441 20	65 70
1977	1946	1433	433 40	79 90
1978	2034	1505	447 40	82 00
1979	2200	1574	528 10	97 90
1980	2295	1598	580 10	116 50
1981	2336	1664	556 50	115 30
1982	2295	1640	541 80	113 00
1983	2259	1625	518 70	115 20
1984	2429	1780	534 30	114 80

Source *National Patterns of R&D Resources Funds and Manpower in the United States 1953-1975 National Patterns of Science and Technology Resources 1984*

NUMERICAL DATA FOR FIGURE 4

NATIONAL EXPENDITURES FOR R&D BY SOURCE: 1966-1984

(Constant 1972 dollars in millions)

YEAR	FEDERAL GOVERNMENT	UNIVERSITIES and COLLEGES
1966	18 180	395
1967	18 176	434
1968	18 107	474
1969	17,209	488
1970	16 316	506
1971	15 615	553
1972	15 808	574
1973	15 594	588
1974	14 826	604
1975	14 537	608
1976	15,072	614
1977	15 382	630
1978	15 878	639
1979	16 407	734
1980	16 541	745
1981	17 124	781
1982	17 841	806
1983	18 622	855
1984	19 577	916

Source *National Patterns of Science and Technology Resources, 1984*

NUMERICAL DATA FOR FIGURE 5

PROPORTION OF NSF AND NIH GRANT FUNDS ALLOCATED FOR PERMANENT LABORATORY EQUIPMENT

YEAR	% of Total Dollars Awarded NSF	NIH
1966	11 2	11 7*
1967	8 6	11 8*
1968	7 5	9 5*
1969	7 0	7 5*
1970	6 1	5 9*
1971	6 3	6 2*
1972	5 6	6 6*
1973	5 5	4 9*
1974	5 4	5 7*
1975	7 4	4 6
1976	7 0	3 9
1977	6 2	4 3
1978	7 3	4 4
1979	8 4	4 6
1980	7 9	3 9
1981	8 6	3 3
1982	9 0	3 2
1983(est)	10 3	3 4
1984(est)	13 9	3 6

*Includes only data from the National Cancer Institute, the National Institute of General Medical Sciences, and the National Heart and Lung Institute

The NSF data is obtained from *Science Indicators*, 1974, and Jim Hoehn, personal communication. The NIH data through 1974 is obtained from *Science Indicators*, 1974 After 1974, the data is from internal NIH files, and reflects the total contribution of grant funds to equipment

NUMERICAL DATA FOR FIGURE 6 NOT AVAILABLE.

NUMERICAL DATA FOR FIGURE 7

FEDERAL SUPPORT FOR RESEARCH AND DEVELOPMENT. 1953-1984

(constant 1972 dollars in millions)

Year	Total	Basic	Applied	Development
1953	4 649	421	1 260	2 9[illegible]3
1954	5,257	444	1 377	3 436
1955	5 754	469	1 381	3 905
1956	7 725	548	1 609	5 568
1957	9 411	627	1 987	6 796
1958	10 280	696	2 222	7 361
1959	11 936	903	2 405	8,629
1960	12 673	1 030	2 442	9 201
1961	13 372	1 214	2 604	[illegible]
1962	14 069	1 546	3 015	9 508
1963	15 671	1 830	3 080	10 761
1964	17 264	2 194	3 442	11 628
1965	17 443	2 415	3 379	11 649
1966	18 180	2 571	3 359	12 250
1967	18,176	2 774	3 398	12 004
1968	18 108	2 837	3 411	11 860
1969	17 209	2 829	3 221	11 159
1970	16 316	2 733	3 377	10 209
1971	15 615	2 641	3,141	9 830
1972	15 808	2 633	3 104	10 071
1973	15 594	2 589	3 234	9 771
1974	14 826	2 589	3 124	9 113
1975	14 537	2 540	3 173	8 824
1976	16 072	2 604	3 434	9 034
1977	15 382	2 718	3 405	9 259
1978	15 878	2 956	3 478	9 444
1979	16 407	3 085	3 592	9 730
1980	16 541	3 128	3 709	9 704
1981	17 124	3 199	3 831	10 [illegible]
1982	17 841	3 160	3 719	10,962
1983	18 622	3 205	3 738	11 679
1984	19 577	3 427	3 701	12 449

Source *National Patterns of R&D Resources Funds and Manpower in the United States 1953-1975 National Patterns of Science and Technology Resources* 1984

NUMERICAL DATA FOR FIGURE 8

FEDERAL NONDEFENSE R&D EXPENDITURES 1975-1984

(Constant 1972 dollars in millions)

Year	Basic Research	Applied Research	Development
1975	1871 6	3188 6	3758 6
1976	1843 7	2[illegible]8	3803 0
1977	2060 6	2[illegible]2	4061 4
1978	2186 5	2987 6	4326 5
1979	2276 9	2936 6	4355 6
1980	2317 0	2915 5	7650 9
1981	2273 7	2651 4	3578 4
1982	2317 7	2549 7	2778 4
1983	2451 1	2617 1	2117 2
1984	2538 0	2360 1	2062 8

Source *National Patterns of Science and Technology Resources, 1984*

NUMERICAL DATA FOR FIGURE 9

PERCENT OF NATIONAL SCIENCE AND ENGINEERING DOCTORAL DEGREES RECEIVED BY NON-RESIDENT FOREIGNERS, SELECTED DISCIPLINES: 1960-1984

Year	Phys Sci	Earth, Marine, Env Sci	Math Comp Sciences	Agricul Sciences	Biolog Sciences	Total Eng
1960	8 89	13 83	15 12	21 98	11 87	16 24
1961	10 70	13 82	13 25	21 00	13 90	16 38
1962	11 20	9 23	16 75	23 82	14 38	17 92
1963	10 78	15 83	12 62	19 31	13 84	15 04
1964	10 41	12 75	13 60	26 11	14 68	14 84
1965	11 24	12 26	11 09	29 86	15 63	15 36
1966	11 52	12 87	12 61	30 38	14 66	16 73
1967	11 57	14 11	11 08	30 03	12 62	15 70
1968	10 25	14 93	11 53	28 65	12 73	15 27
1969	9 77	15 38	10 65	27 93	10 93	14 08
1970	9 32	13 92	10 93	24 75	10 74	13 71
1971	9 19	8 15	12 27	26 24	8 53	14 80
1972	10 59	10 59	13 19	27 16	8 47	14 81
1973	12 68	11 51	14 03	27 36	12 16	18 [illegible]8
1974	13 16	16 05	18 49	33 04	10 41	22 37
1975	14 88	14 98	17 17	29 50	9 06	27 14
1976	15 06	14 88	18 24	30 96	8 76	28 68
1977	14 92	14 40	17 63	32 86	9 13	29 24
1978	15 20	10 [illegible]1	18 87	31 30	8 30	31 69
1979	15 51	10 99	21 75	30 99	8 14	32 73
1980	16 89	12 73	18 91	32 45	7 78	31 32
1981	16 32	14 57	23 54	33 09	7 57	37 26
1982	18 78	12 32	26 70	27 33	8 81	38 92
1983	19 23	16 64	28 47	30 24	8 61	42 07
1984	19 82	17 26	32 29	31 29	9 29	43 49

Source Foreign Citizens in U S Science and Engineering History Status, and Outlook,' Prepared by National Science Foundation, Directorate for Scientific Technological, and International Affairs Division of Science Resources Studies Table B-21

APPENDIX I

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