THE DIRECTOR'S STATEMENT

The Foundation in Retrospect

This 15th annual report of the National Science Foundation seems to me a suitable point from which to look back across the years that have passed since the National Science Foundation Act was passed by the 81st Congress and signed by President Truman on May 10, 1950. The timeliness of such a look is enhanced by the review of Foundation activities initiated in fiscal year 1965 by the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics (U.S. House of Representatives, 89th Congress). Testimony presented to the Subcommittee by many individuals from within and outside the Government along with comments and observations by Subcommittee members combined to provide a well-rounded, objective picture of the Foundation and its relationship to national purposes.

Creation of the National Science Foundation as a unique agency of the Federal Government was the result of two factors directly related to the massive impact of World War II. The first of these was the explosive technological development that accompanied the war, and irrevocably altered for all time the tone and fabric of the American social structure. Second was the fact that the national store of unexploited fundamental scientific knowledge was virtually bankrupt as a result of technological pressure, a condition made even more parlous by the enforced interruption of the education of young scientists and engineers.

J. Robert Oppenheimer, wartime director of the Los Alamos Scientific Laboratory, later testified that "we learned a lot during the war," and his words might well have been echoed by many others. "But," he continued, "the things we learned (were) not very important. The real things were learned in 1890 and 1905 and 1920, in every year leading up to the war, and we took this tree with a lot of ripe fruit on it and shook it hard and out came radar and atomic bombs. . . . The whole spirit was one of frantic and rather ruthless exploitation of the known; it was not that of the sober, modest attempt to penetrate the unknown." Thus it may be said in a sense that technology was treading on the heels of science when the war ended.

Many of the dramatic technological developments of the war were the result of "crash" programs conducted in an atmosphere of urgency at some of our major universities, and as hostilities neared an end the implications for science and technology in the years of peace ahead were visible, if yet undefined.

In late 1944, President Roosevelt addressed a request to Dr. Vannevar Bush, director of the wartime Office of Scientific Research and Develop-

ment, for advice as to how the lessons learned in war could be applied to the pursuits of peace. With the help and recommendations of four committees of scientists and other scholars, Dr. Bush set forth in clear and specific terms what he felt the relationships of government to science should be, and how they should be sustained. His imaginative and stimulating report, *Science, the Endless Frontier,* was to have a profound and lasting impact on the future of American science.

The Bush report pointed out that there was at the time no national policy with respect to science. Government interest in and patronage of the sciences dates back to the earliest days of the Republic, with varying degrees of emphasis in accordance with circumstances or requirements of the moment. But the war and its consequences brought both opportunity and responsibility for the Federal Government to utilize science in promoting the national welfare on a scale never before envisioned. "Science," wrote Dr. Bush, "has been in the wings. It should be brought to the center of the stage—for in it lies much of our hope for the future."

This call for a place in the sun for science was inspired by vision of the great potential for the future, and not in deprecation of the accomplishments of American science in the past. Rather it articulated a coming of age for science in this country, and a fuller appreciation of science as a viable and dynamic social force.

One of the most important recommendations of the Bush report was that there be established within the Government a unique agency to serve as a focal point for the support of scientific research and science education, but resembling in many respects some of the private foundations and organized in such a way as to be sensitively responsive to the general scientific community. This was the conceptual origin of the National Science Foundation, as described by Dr. Bush.

A Broad Congressional Mandate

Public Law 507, the implementing legislation passed by the 81st Congress in 1950, was described as an "act to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense; and for other purposes."

Specifically the act authorized and directed the Foundation to:

- develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences;
- initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering, and other sciences, by making contracts or other arrangements (including grants, loans, and other forms of assistance) for the conduct of such basic scientific research and to appraise the impact of research upon industrial development and upon the general welfare;

- at the request of the Secretary of Defense, to initiate and support specific scientific research activities in connection with matters related to the national defense . . .;
- to award scholarships and graduate fellowships . . .;
- to foster the interchange of scientific information among scientists in the United States and foreign countries;
- to evaluate scientific research programs undertaken by agencies of the Federal Government, and to correlate the Foundation's scientific research programs with those undertaken by individuals and by public and private research groups;
- establish special commissions . . . necessary for the purposes of this Act;
- to maintain a register of scientific and technical personnel and in other ways provide a central clearing house for information covering all scientific and technical personnel in the United States . . . .

Although some amendments to the legislation of 1950 have subsequently been enacted, notably in the policy-making area, the broad responsibilities and functions outlined in the original act have provided the framework within which the Foundation has developed to its current status. I believe that a statement made by Dr. James B. Conant, first chairman of the National Science Board, and published in the first annual report of the Foundation, is worthy of review from the distance of 15 years. It spells out a philosophical departure point, and establishes a sense of direction for operational doctrine of the Foundation which remains substantially valid to the present.

"Both types of research (basic and applied) are of the utmost importance—important for advancing industry, public health, national defense, and extending the boundaries of knowledge, but today in the United States it is the uncommitted investigator who stands in the greatest need of public support. He needs not only more money for his equipment and for helping hands but more public recognition for the significance of his work, for he is the scientific pioneer, the man who turns the unexpected corner, the laboratory man whose experiments mark the opening of a new era or the theorist whose ideas are so fruitful as to be revolutionary. By and large the United States has not yet produced its share of such scientific pioneers compared with Europe. One of the purposes of the National Science Foundation is surely to right this balance and provide in every section of the country educational and research facilities which will assist the development of such men.

"In the advance of science and its application to many practical problems there is no substitute for first-class men. Ten second-rate scientists or engineers cannot do the work of one who is in the first rank. Therefore, if the aims of Congress as set forth in the National Science Foundation Act are to be fulfilled, there must be all over the United States intensive effort

to discover latent scientific talent and provide for its adequate development. This means strengthening many institutions which have not yet developed their full potentialities as scientific centers, it means assisting promising young men and women who have completed their college education but require postgraduate training in order to become leaders in science and engineering . . . . Given time, the expenditure of public funds in this enterprise, I feel certain, will prove to have been a most advantageous investment by the American people."

Organization of the Foundation

The organizational structure of the Foundation provides a form of dual authority and dual responsibility, one of the few examples of such an arrangement among nonregulatory agencies of the Government. On the one hand there is the National Science Board, a 25-member policy-making component of the Foundation as established by the original enabling legislation. The Board is composed, now as in the past, of distinguished individuals from outside the Government, drawn mostly but not entirely from the scientific disciplines, and all appointed by the President "with the advice and consent of the Senate." The Director is an ex officio member. In addition to its policy-making function, the Board constitutes one of the Foundation's most important avenues of communication with the scientific and educational community.

The Director of the Foundation, on the other hand, is a salaried Presidential appointee who serves as chief executive officer of the Foundation, with specific statutory responsibility assigned within the broader framework of policy established by the Board. A close and harmonious partnership between these two organizational elements has characterized the operation of the Foundation from the beginning. During recent years, however, with a substantial increase in the scope of overall activity, it has become necessary to re-examine functions and responsibilities and make certain modifications in the light of pressing realities.

At the outset, and during the initial years when the scope of Foundation activity was limited, the Board was required by the National Science Foundation Act in its original form to review and approve every grant or contract made by the Foundation. As the volume of funding available for support increased, however, the workload involved in this process placed an unduly heavy demand on the time and attention of the Board, and it became obvious that a change in the procedure was indicated.

Public Law 86–232 of September 8, 1959, as a consequence, provided for delegation of powers and duties from the Board to the Director, including the delegation of authority to authorize funding of projects. The intent of this was to relieve the Board of some of the burden of review and approval of smaller (but numerous) grants. An arrangement devised by the Director and the Board provided for a financial ceiling beneath which the Director was authorized to approve grants independently. The act of 1959

additionally modified the wording of portions of the original legislation to expand the scope of authority for the Foundation.

Further clarification of the relationship between the Director and the National Science Board was delineated in Reorganization Plan No. 2 of 1962. Whereas previously the Director had been an ex officio nonvoting member of the Board, he was then designated, ex officio, a voting member on a basis coordinate with that of other members. In addition to this and other provisions aimed at improving administrative effectiveness, the Reorganization Plan stipulated that the Director was to be chairman (and a voting member) of the five-member Executive Committee of the National Science Board.

Assignment of additional authority to the Executive Committee (by Reorganization Plan No. 2) had the effect of streamlining the Board's exercise of responsibility. The Board was authorized to assign to the Executive Committee such of its powers and duties as were deemed appropriate, except for the function of establishing policy.

More recently additional structural changes within the Board have been made desirable by the rapid evolution of Foundation operations. In earlier years, the Board organized itself into working committees paralleling the various scientific disciplines supported by the Foundation, as well as committees covering such operational areas as scientific personnel and education and institutional programs.

As the need for a broader viewpoint in coordinating and integrating the various programs of the Foundation became manifest, in 1965—at the suggestion of the Director—the Board reorganized itself into three major committees, replacing the former numerous and more restricted working groups. Rather than attempting to name these, they were simply designated Committees I, II, and III.

The purpose of Committee I is defined as examination of matters of broad scientific significance as related to current Foundation programs. This function includes continuing scrutiny of the distribution of Foundation efforts among the various scientific disciplines which may legally be supported, and among the various kinds of activities the Foundation supports, such as research, education, and science information. An important aspect of this continuing operational analysis is examination of Foundation support for the new and expanding sciences and the degree of support these areas are receiving from other Government agencies or from industry. In general, this committee deals with substantive scientific matters of concern to the Foundation and, as a result, of consequence to national policy.

Committee II concerns itself with the operational and administrative aspects of the Foundation, and how these affect and are affected by Foundation relationships with other organizations. Major areas of interest to this committee cover the internal organization of the Foundation, the administrative procedures involved in judging the merit of research proposals, the perennial problem of "overhead" allowances, the policy to be adopted

relative to "cost sharing," the percentage of faculty salaries covered by Foundation support, and the effect of Foundation and other Federal programs on the universities' ability to meet the expenses normally associated with grants.

Committee III devotes its attention to long-range planning, and is charged with looking to the estimated level of support for science five or ten years in the future, and deliberation on possible future programs which may involve the Foundation and other Federal agencies with respect to national purposes.

This arrangement has a number of advantages over the earlier pattern. The Board, in only intermittent contact with Foundation operations in any circumstances, is relieved of much attention to detail. Fewer meetings of the full Board are now required, and the Executive Committee can be called into session quickly if rapid action should become necessary.

As the Board has moved toward greater relative emphasis on broad and long-range policy as compared to the details of routine operation, its usefulness to the scientific community and its value as a component of the Foundation have increased. The tendency toward less involvement in operational decisions results in more critical analytical scrutiny of Foundation policy and the policies of Government for science as a whole.

An additional and important system of continuing communication with the scientific and academic communities is maintained through Divisional Committees* composed of educators and scientists appointed to advise the Director on overall program activities. The judgment of these committees has proven to be of immeasurable value in determining both broad and specific approaches to providing support for basic research and science education.

Further informative services are available to the Foundation staff through Advisory Panels comprised of individuals representing specific scientific disciplines. Members of these panels are university faculty and industrial research personnel, and in some cases representatives of agencies of the Federal Government. Several hundred persons, each an authority in his field, serve on these panels.

Foundation Responsibility for National Science Policy

With respect to its responsibility "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences," the Foundation first approached this task with deliberation. "National science policy" is a term that is difficult to define save in the broadest generalities. It is rather a constellation of interrelated policies. These may be grouped together as "national science policy" because they

*Subsequent to the period covered by this report these committees have been reconstituted and consolidated to form "Advisory Committees" with somewhat broader responsibilities.

affect, directly or indirectly, the level, substance, and conduct of scientific activities in the United States, the opportunities for and content of education in the sciences, and the utilization and development of the Nation's resources for science.

Science policies are shaped by State and local governments, by nongovernmental institutions, enterprises, and organizations as well as by the Federal Government. It is appropriate therefore to think of the national policy for science as a composite of both public and private science policies.

But if there is to be any coherence in such a set of science policies, it is essential that there be a body of reliable information on the status of scientific manpower, facilities, and funds, including data on their distribution by performer groups, by geography, by level of competence, and by field of science.

It was to this need in the realm of policy that the Foundation addressed its initial efforts by instituting a continuing series of studies, data acquisition, and analyses of government and nongovernment activities in an effort to compile a unified picture of the whole. Activities in this connection have become fairly substantial, although commanding only modest funding, and Foundation publications have become the standard source of information on the Nation's supply of scientific and engineering manpower and statistical data on the total national effort in scientific research and development as a whole.

Some of the substantive activities in support of science policy formulation are *Federal Funds for Research, Development, and Other Scientific Activities,* an annual statistical analysis; the National Register of Scientific and Technical Personnel; and the Science Information Exchange maintained by the Smithsonian Institution with the support of the Foundation.

The role of the Foundation with respect to policy-making for basic research and science education was modified to a degree by Reorganization Plan No. 2 of 1962 which also created the Office of Science and Technology in the Executive Office of the President. This plan provided for transfer from the Foundation to the Director of the Office of Science and Technology so much of the function "to develop and encourage the pursuit of a national policy" as will enable the Director of the Office of Science and Technology "to advise and assist the President in achieving coordinated Federal policies for the promotion of basic research and education in the sciences."

Statutory responsibility of the Foundation in the broader context beyond the perimeters of the Federal complex remained unchanged, and the Foundation retains full intellectual responsibility to examine current policy, to make recommendations, and to take action with regard to strengthening the various fields of science. At the same time, the Foundation supports the Office of Science and Technology through continuing studies which assess research opportunities in the sciences, and through recommendations

for consideration by the Office of Science and Technology in the planning of overall Federal scientific activity.

In parallel fashion, the Foundation also supports the Federal Council for Science and Technology, which is composed of representatives of the Federal agencies having a substantive interest in science and technology. While the Federal Council serves as a coordinating body, and is concerned with both formulation and suggestion of policy, the Foundation has a statutory responsibility over and above the other agencies to assemble information and present recommendations upon which sound Federal policies for science can be based.

Foundation Support of Basic Research

Although establishment of the National Science Foundation in 1950 constituted Federal recognition of the need to support basic research in the sciences, initial funding provided for the Foundation by Congress was modest. Six years had passed between publication of the report *Science, the Endless Frontier* and the Foundation's first year of activity, bringing with them a change in circumstances that could not have been foreseen by Bush and his associates. Partly because of the exigencies of the quickening Cold War and the conflict in Korea, a number of Federal agencies were already engaged during the early 1950's in substantial programs of support for scientific research, including basic research, and for improvement of science resources.

Even the agencies with rather specific technological objectives rightly justified their support of basic research in recognition of the general need to replenish the reservoir of unexploited basic knowledge. Thus, while the Government was proceeding in the direction of goals envisioned by Bush and Conant, such agencies as the Department of Defense and the Atomic Energy Commission were important vehicles through which Federal funds found their way to science. It was during this period too that the National Institutes of Health began to assume prominence as a source of support outside its own research institutes.

This pattern of pluralistic support for basic research has endured, and has been found to contain a number of advantages. It is favored by the colleges and universities. It has always been endorsed and fostered by the Foundation as sound and appropriate.

The Foundation placed emphasis from the beginning on support for the highest quality of basic research. In fiscal year 1952, the first year in which funds for the purpose were available, the Foundation awarded 96 grants for project research at 59 institutions located in 33 States, the District of Columbia, and Hawaii. The direct grant was chosen from the outset as the most appropriate type of instrument for supporting basic research on the basis that it would provide maximum latitude and academic freedom to qualified investigators, while entailing a minimum of administrative involvement for the institution.

A significant advance in support of research took place in 1956 when the Foundation for the first time provided major assistance for procurement of science facilities, with one grant awarded for construction of a nuclear reactor, and the first five grants in a series providing support for computers at universities.

The year 1956 also saw the preliminary steps which led to establishment of the National Radio Astronomy Observatory at Green Bank, W. Va., and the Kitt Peak National Observatory in Arizona, both now operated for the Foundation by consortia of universities. A study initiated in the same year by the National Academy of Sciences on the gap between performance and potential in the atmospheric sciences led to establishment in 1960 of a third national research center: the National Center for Atmospheric Research at Boulder, Colorado—also operated by an association of universities. These national centers now provide modern facilities for use by significant numbers of visiting university scientists and graduate students, and thus constitute effective extensions of university research activities.

Support for the scientific aspects of *Vanguard,* America's first artificial satellite, and participation by the United States in the International Geophysical Year (IGY) made 1957 a year of notable expansion for the Foundation. The IGY, a comprehensive worldwide scientific undertaking, was the first "national" research program in which the Foundation shared, and was the precursor of a number of others. As the Federal agency uniquely concerned with basic research, the Foundation has come to be regarded as the most appropriate executive agent for coordination and, in some cases, financial management of broad scientific programs in which a number of departments and agencies of the Federal Government participate, along with nongovernmental entities, and often in cooperation with other nations on an international basis.

National research programs are usually undertaken at the initiative of the scientific community, which may request support from the Federal Government after the desirability of U.S. participation has been established. The National Academy of Sciences has been an important intermediary between the scientific community and the Federal Government in such matters, and usually provides continuing advisory services to the Foundation after a national research program has been initiated. Authority to participate in national research programs may arise from the Foundation's organic legislation, by specific legislative acts covering a particular program, or by executive order (which is usually the case with reference to international programs).

Foundation responsibility for national research programs covers two general categories:

1. Programs in which the United States participates as a component of an international group under the auspices of intergovernmental or multinational science organizations. Examples of these are the Antarctic Research Program and the United States-Japan Cooperative Science Program,

for both of which the Foundation bears complete United States responsibility including funding;* and the International Indian Ocean Expedition and the International Years of the Quiet Sun, for which the Foundation is the coordinating agency.

2. Programs which are entirely domestic and which involve basic research, such as Project Mohole, ocean sediment coring, and weather modification.

Foundation responsibility for weather modification is defined in Public Law 85–510 of 1958 which amended the original National Science Foundation Act to add: "to initiate and support a program of study, research, and evaluation in the field of weather modification, giving particular attention to areas that have experienced floods, drought, hail, lightning, fog, tornadoes, hurricanes, or other weather phenomena, and to report annually to the President and the Congress thereon."

There is a third category of national research programs that should be mentioned. These are designated by the Federal Council for Science and Technology and embrace scientific fields that depend substantially on Federal support but in which the responsibility is not so sharply focused in any one agency. Among this category are included the atmospheric sciences, materials research, oceanography, and water resources research. The Foundation participates in all these programs, but only as one of several agencies having an interest in the various fields.

Other programs of support for research added gradually by the Foundation over the years were devised to provide support for major items of equipment such as nuclear accelerators, and specialized facilities such as oceanographic research vessels and environmental laboratories for biological research. Funds have also been provided on a matching basis for construction or renovation of graduate laboratories in a large number of academic institutions.

Support of Science Education

Like the support provided for basic research, Foundation activity in the field of science education dates back to the first full year of operation. Statutory authority for the Foundation to support science education arose from the need to develop an adequate national supply of scientific and technical manpower rather than support for education per se. Foundation policy, however—as in the case of research—placed emphasis from the outset on quality rather than quantity, and support of graduate education became a first priority concern.

The initial program of graduate fellowships for the academic year 1952–53 provided awards at both the predoctoral and postdoctoral levels to 624 candidates selected on the basis of national competition. This emphasis

*The Department of Defense has responsibility for logistic support of the scientific programs in the Antarctic with the U.S. Navy designated as executive agent.

on academic excellence endures as a cornerstone of Foundation policy, and the graduate fellowship program is regarded as one of the Foundation's most effective mechanisms in support of science education. In addition to quantitative expansion of the traditional fellowship program, the Foundation has added specialized variations, notably two postdoctoral programs which provide advanced training for exceptionally able individuals who wish to become even more effective in their fields, and science faculty fellowships for college and university science teachers with the primary aim of enhancing their capability as teachers of undergraduate students.

The Foundation early recognized that the acute shortage of scientific and technical manpower in the early 1950's had deep roots in the educational, social, and economic structure of the Nation, and that correction would require long-range efforts aimed at the basic problem areas. Thus Foundation interest in science education was expanded as rapidly as possible to touch on every level of the education process from primary school to the highest level of postdoctoral study.

New programs have been developed by the Foundation over the years in a continuing effort to discharge its responsibility for science education more fully. Generally speaking, the programs in support of science education have three broad objectives: (a) to assist qualified individuals in obtaining additional advanced training, (b) to improve the quality of curricular material and the methods used in science teaching, (c) to improve the level of knowledge and other qualifications of science teachers.

In fiscal year 1953, the Foundation sponsored its first summer institutes to assist college science teachers in coming up to date with the latest developments in their specialties, with 250 teachers from small colleges participating. In the following summer the institutes program was expanded to secondary school teachers. At the present time, the Foundation institutes programs reach teachers of science, mathematics and engineering from the elementary to the undergraduate level, and are organized and conducted by several hundred colleges and universities. The summer group-training sessions are further augmented by inservice training of teachers at evening classes and a smaller number of academic-year institutes given to teachers who have taken a leave of absence for the purpose of pursuing additional training. Altogether Foundation support for teacher training of this type has provided some 300,000 training opportunities.

A related activity in support of science education is the Foundation effort to provide colleges and universities with undergraduate instructional equipment. On a cost-sharing basis the Foundation provides assistance in procurement of laboratory equipment for undergraduate science programs, and this type of assistance has proven particularly beneficial to large numbers of smaller colleges. The present level of this type of support for science education is about 950 grants annually to more than 500 institutions.

For a number of years the Foundation has provided support for efforts directed to improving the curricula of science courses at both the precollege

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and undergraduate levels. Grants have been made to support outstanding scientists and teachers of science who, working in partnership, have incorporated the most up to date scientific knowledge into textbooks and other instructional media and the results produced by these partnerships have won widespread endorsement throughout the educational community.

Science Information Service

Acceleration in all avenues of scientific activity in the latter years of the 1950's brought with it new recognition of the need for better coordination in the dissemination of science information. While the Foundation from its inception expressed interest in this general problem area by supporting a number of science information activities, this participation by the Foundation was voluntary and permissive under the broad mandate of the original authorizing legislation rather than as the discharge of a specific statutory responsibility.

The Congress in 1958 moved to strengthen and expand the Foundation's information function by incorporating into the National Defense Education Act a provision for establishment of an Office of Science Information Service within the Foundation (Title IX, NDEA). The act also called for establishment of a Science Information Council to be appointed from nongovernmental authorities in such fields as librarianship, scientific documentation, and communications, and having as its purpose to serve in an advisory capacity to the Office of Science Information Service.

As it is now constituted, the Office of Science Information Service is responsible for providing leadership among non-Federal science information services, and in developing appropriate relationships between Federal and non-Federal activities. The function of coordinating scientific and technical information services within and among the Federal agencies rests with the Office of Science and Technology and a committee of the Federal Council for Science and Technology. Thus the objective of the Foundation's Office of Science Information Service is to supplement internal Federal information activities, and insure that scientists and other users have ready availability to the world's current and past output of significant scientific and technical literature.

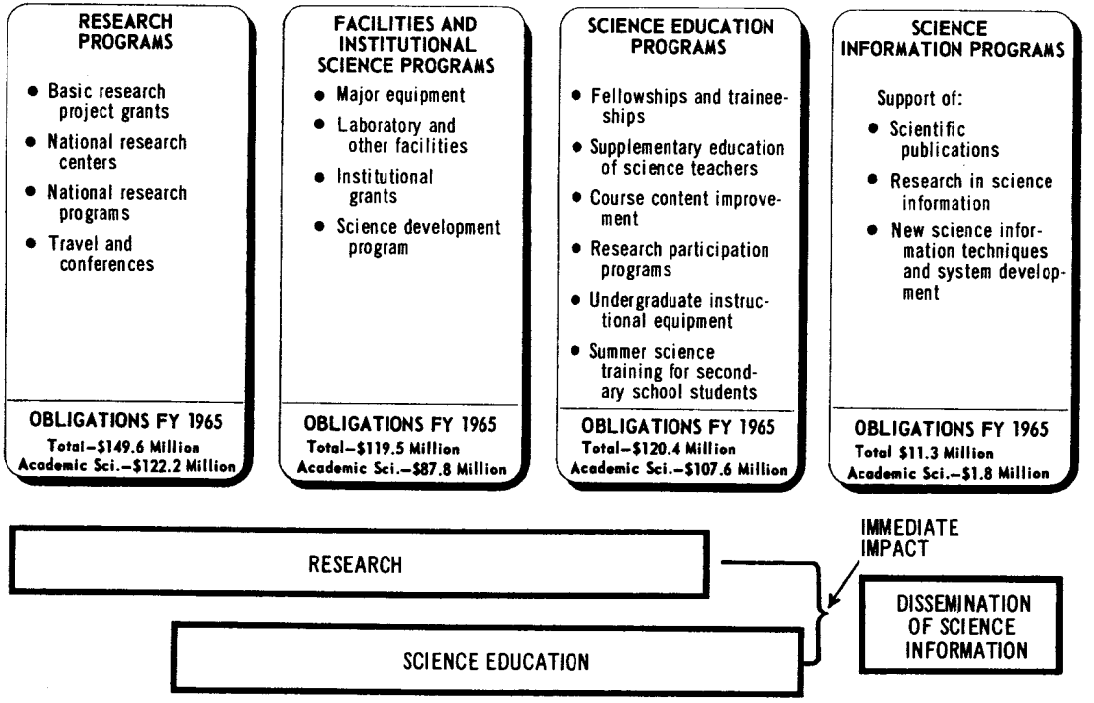
Categories of Support

The complex of support mechanisms now employed by the Foundation at the conclusion of 15 years of evolution is illustrated by chart 1. For administrative convenience, the various activities are here arranged in four main categories, but this of course is an oversimplification in terms of the purpose and impact of the various programs. Many programs, notably those listed as Facilities and Institutional Science Programs, have a duality of purpose because of the interlocking nature of research and education, especially at the graduate level where the two are virtually indistinguishable. Even the

MECHANISMS OF SUPPORT

NATIONAL SCIENCE FOUNDATION

Chart 1



SOURCE: National Science Foundation

dissemination of science information is a form of support for research on the one hand, while it unquestionably has a usefulness in promoting advanced education on the other. And just as the various activities generally have an impact on both research and education, so the allotment of funding among the four categories is somewhat arbitrary, assignments being made in terms of the primary purpose of the program although it may very well have multiple effects.

The national research centers provide a good example of this duality of purpose, in that about 60 percent of the research done at the two astronomical observatories is conducted by university scientists and graduate students. Similarly, a substantial portion of research carried out in the Antarctic is performed by university scientists from many parts of the United States.

Of approximately $400 million obligated outside the Foundation in fiscal year 1965, almost three-fourths was committed directly to the country's academic institutions (see chart 2). Another 6 percent went to individuals in the form of fellowships which enabled them to pursue graduate study at these institutions.* Furthermore, a substantial fraction of the funds obligated to "other nonprofit organizations" supports the basic research in which academic scientists participate at the national research centers, as mentioned above, as well as curriculum development and other science education activities which benefit the colleges and universities or other parts of the national educational structure. In addition, nearly all the funds allocated to industry are for the purpose of providing facilities that will be used for research closely associated with scientists in colleges and universities. Thus it may reasonably be said that well in excess of 90 percent of the Foundation's total program is directly or indirectly in support of academic research or science education.

About 1,100 academic institutions in the United States offer programs leading at least to a bachelor's degree in the sciences or engineering. Approximately 1,000 more, including 650 junior colleges, provide more limited amounts of undergraduate training in science. Some 176 universities in the Nation provide training to the Ph. D. level in one or more fields of science.

Altogether, 834 colleges and universities were direct recipients of Foundation funds for academic science during the fiscal year covered by this report. Academic science, used in this context, refers to all types of support having a significant and direct impact on the colleges and universities. In its research support program, the Foundation provided funds to about 300 institutions. Half of these received $70,000 or more during the fiscal year, and each of the top 100 institutions received $200,000 or more.

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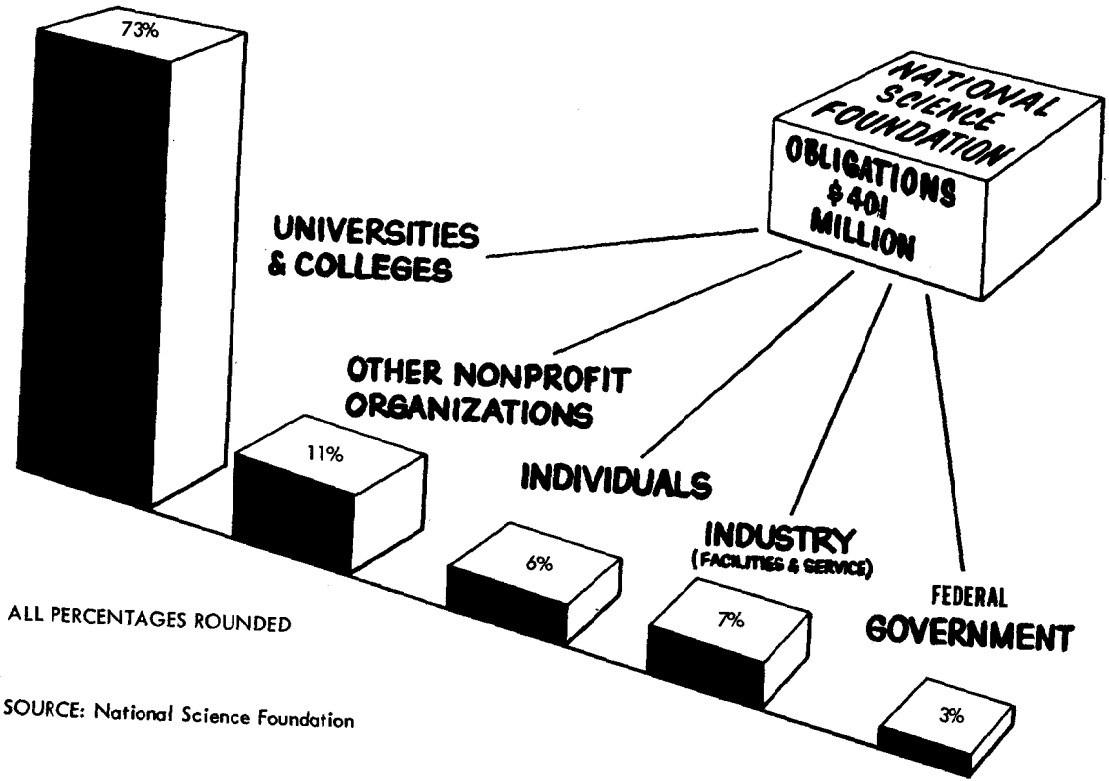
*This refers only to the costs of fellowships awarded directly to individuals. Funds for "traineeships" awarded by the universities are included in the category "universities and colleges."

DISTRIBUTION OF FUNDS FOR DIRECT SUPPORT OF SCIENCE FY 1965

NATIONAL SCIENCE FOUNDATION



ALL PERCENTAGES ROUNDED

SOURCE: National Science Foundation

Chart 2

The table below illustrates the relationship between support for academic science by the Foundation and the number of degrees awarded during the previous academic year by the institutions supported. As the figures show, institutions receiving support accounted for 99.8 percent of the doctorates awarded, 99.4 percent of the master's and 89.8 percent of the bachelor's degrees earned in the sciences and engineering.

Highest science or engineering degree awarded 1963–64	Fraction of NSF funds, fiscal year 1965	Fraction of degrees conferred—1963–64 (by institutions awarded NSF funds in fiscal year 1965)		
		Ph. D.	Master	Bachelor
	Percent	*Percent*	*Percent*	*Percent*
Ph. D	88.8	99.8	86.7	52.7
Master	7.3	.....	12.7	21.7
Bachelor	3.7	.....	.....	15.4
No degree	.2	.....	.....	.....
Total	100.0	99.8	99.4	89.8

Further examination of statistics reveals the characteristic which has been described as "institutional imbalance" in support. As seen in the following table the first 200 institutions received 93.4 percent of support provided (with a corresponding record of 97.9 percent of the doctorates awarded), while 234 of the 834 institutions supported shared among them only 3/10 of one percent of Foundation funds for academic science although they graduated 6.2 percent of the science baccalaureates. In the same context, however, it is notable that of the 176 institutions offering programs leading to the Ph. D. degree, only four did not receive support, and these four together accounted for only 18 of the nearly 9,000 doctorates earned during the year.

It is clear that there is a wide qualitative disparity between the leading institutions of higher education and those at the lower levels. But there is more basis for the belief that Federal funds in general are attracted to outstanding institutions because of their quality than for the contrary view that this high quality is the result of Federal support. In any case, it has become increasingly recognized with the passage of time that the future needs of the Nation demand a larger number of institutions of high caliber, with an increased cadre of well-qualified scientists and science educators, with facilities adequate to the requirements of modern research and educational problems, and with an increasing number of opportunities for advanced research and advanced research training.

The Foundation has several programs directed at supporting the institutions, as distinguished from those supporting specific projects within the institutions. A special form of institutional assistance, in existence since

Institutions in order of NSF support, fiscal year 1965	Fraction of NSF support fiscal year 1965	Fraction of total earned degrees in science and engineering—1963–64, awarded by NSF-supported institutions		
		Ph. D.	Master	Bachelor
	Percent	*Percent*	*Percent*	*Percent*
First 10	24.6	28.4	18.6	7.9
Second 10	16.0	11.3	7.6	3.6
Third 10	11.8	11.8	7.5	4.8
Fourth 10	8.2	11.8	7.9	5.1
Fifth 10	6.1	7.1	7.7	3.9
First 50	66.7	70.4	49.3	25.3
Second 50	16.8	19.6	22.8	15.6
Third 50	6.5	6.4	11.8	10.8
Fourth 50	3.4	1.5	5.8	8.0
First 200	93.4	97.9	89.7	59.7
Second 200	5.0	1.6	7.0	15.2
Third 200	1.3	.3	2.1	8.7
Remainder (234)	.3	.....	.6	6.2
Total supported	100.0	99.8	99.4	89.8

1961, is the "Institutional Grant," an annual award of funds based on a formula related to the volume of research support provided to the institution by the Foundation. These funds may be used for any purpose which directly supports academic science.

Among the typical purposes for which such funds may be used are: rental of computer time, acquisition of scientific equipment, outfitting of shops, stocking of libraries, student stipends, or salaries for additional faculty. The flexibility inherent in this type of assistance makes it particularly desirable from the viewpoint of the institution involved. An important aspect of this program is that the formula used to determine the amount of the grant is one which favors the smaller or weaker institutions—or, more precisely, it tends to favor the institutions receiving the smaller amounts of direct research support.

During recent years a number of previously less prominent institutions have attained new stature, and the Foundation has adopted various measures aimed at stimulating and accelerating this trend among what have been called the "rising universities." Among these is a new form of institutional support introduced in fiscal year 1965 aimed at broad and rather rapid development of a limited number of institutions having a demonstrated potential for advancement toward the level of excellence which is now characteristic of our truly outstanding institutions.

This new form of support, called the Science Development Program, is considered to be important and promising, and it contains a broad degree of flexibility which will enable the institution to accelerate progress toward achieving its objectives on the basis of plans carefully worked out by the institution itself. During fiscal year 1965, eight grants of this type were awarded, averaging $3.4 million each, to institutions in various parts of the country.

In announcing the first of these Science Development grants President Johnson said: "These grants are only a beginning . . . . This new program will build the apex on the educational pyramid while our other programs broaden and strengthen the base. These are important steps in maintaining the scientific leadership which this country has achieved."

There is reason, accordingly, to hope that this program can be expanded substantially during each of the next several years. I believe that, by providing a major boost through such Science Development grants, the Foundation can assist in bringing the recipient institutions to a position from which they can continue to develop on their own momentum and with their own resources.

During fiscal year 1965 the Foundation staff has been carefully exploring possible ways of implementing an additional type of institutional support, a program designed to reach those institutions which have not yet reached a position of sufficient general strength to enable them to compete strongly for grants under the Science Development Program. This new program will be directed toward further development of "pockets of strength" in specific scientific disciplines which now exist and can be identified in many institutions across the country. It is felt that even one science department which is substantially above average can be of general as well as specific usefulness to the institution in which it exists. The impact of such a nucleus of quality will have an immediate effect on related departments, and will eventually spread to all scientific disciplines represented on the campus.

Another innovation recently initiated by the Foundation is the Graduate Traineeship Program, which is directed toward fuller utilization of the capacity of a large number of institutions to provide training for graduate students in the sciences and engineering. Recipients of regular Foundation fellowships have always been free, as stipulated by law, to attend the institution of their choice, and there has been a natural tendency for them to concentrate at a relatively small number of leading institutions. In the Graduate Traineeship Program, initiated in fiscal year 1964, the institution applies for the number of traineeships it believes it needs in the various eligible fields of science. Grants are awarded on the basis of departmental strength and capacity for expanding the graduate student enrollment. Ultimate selection of the individual recipients is made by the institution from among its own graduate students or undergraduates entering upon graduate training. During its first year the Traineeship Program was limited to the engineering fields. In fiscal year 1965 it was expanded to include mathe-

matics and the physical sciences, with grants being given to almost all universities granting doctorate degrees in the fields eligible. It will be still further broadened in fiscal year 1966 to include the biological and social sciences. In addition to assigning specific numbers of traineeships for particular disciplines, the Foundation additionally allots a number of unrestricted or "floating" traineeships which may be utilized by the institution at its own discretion.

One important aspect of the Traineeship Program is its developmental effect. It gives the institution an opportunity to attract more good graduate students, and this aspect will grow in importance as the program expands. Following the introduction of traineeships, the Foundation is now phasing out its older cooperative fellowship program and diverting the funds used for these to an increase in the number of traineeships and conventional graduate fellowships.

Climate of the mid-1960's

Since the war, science has enjoyed unprecedented and rapidly growing Federal support. Initially this support was primarily directed at immediate exploitation of the practical fruits of science in pursuit of national objectives in such fields as military defense, public health, conservation of natural resources, and industrial development. Federal agencies with responsibilities in these and other technological areas were motivated to support basic research as the source of underlying knowledge necessary for achievement of these goals. Increasingly it has become recognized that continuance and growth of the fruits of science can occur only if the tree that bears them—science itself—is helped to grow and flourish. Federal support for research and development as a whole has approximately doubled since 1960—from $8.1 billion to $16.1 billion—but it is notable that the development share has less than doubled while the support for basic research has more than tripled.

This change in attitude toward the importance of basic research has been accompanied by other changes which have emerged at an accelerating pace, and the concept of Federal support has now been broadened across a wider range of intellectual activity without any diminution in the objectives of science and science education. There is increasing discussion of Federal support for the arts and humanities,* and after long hesitation the concept of Federal support for education in general is now wholly accepted.

The most dramatic and progressive of these changes in the national attitude is, of course, Federal support for education at all levels. Appropriations for the Office of Education have increased about sevenfold in the years from 1960 to the present, and legislation pending at the end of fiscal

*The act establishing a National Foundation for the Arts and Humanities was signed by the President on Sept. 29, 1965, after the period covered by this report.

year 1965 can be expected to bring even further increases. Two impelling motives are at the base of these changes. The first results from recognition that a highly educated people makes the Nation strong in a composite sense; that for our national well-being we must develop the highest competence in all fields of human endeavor; and that to achieve this we must have high quality education at every level.

Secondly, and importantly, Federal policy has evolved in the direction of stronger emphasis on the democratic principle that every citizen is entitled to an opportunity for the best education he has the capacity to absorb effectively, and in the field he finds best suited to his talents.

There is nothing new in principle in these developments, so far as national philosophy is concerned. Public support of education for both of these motives goes back to colonial times. What is new is that in the structure of modern society the Federal Government must share responsibility for attainment of the goals.

This trend is accompanied, though as yet in less full and evident fashion, by an increasing acceptance of the value of scholarship and intellectual activity, not only for potential material rewards, but for its role in fulfillment of the human personality and development of human intellect for their own sake.

Clearly there is a pervasive mood in all parts of the country to improve education at every level, and the general interest extends higher up the educational ladder than ever before. It is my view that there is no reason to believe that science will suffer by sharing the spotlight of Federal support with other branches of scholarship. Rather science can be expected to prosper all the more as a climate more favorable to scholarship in general is developed. Government is committed to the continued support of academic science, and while there may be shifts of emphasis or modifications in levels of support of this type, I see no reason to anticipate any change in basic policy. Support of science for its own sake will, I believe, increase—in absolute amount at least, and probably also as a fraction of the Nation's total investment in science and technology.

The scientific community has played an important role in bringing about the growing interest in all areas of cultural activity and the current intensive popular interest in improving education. The attainments of science, visible for all to see, have demonstrated the public and individual benefits deriving from intellectual accomplishment and higher education. The example set by Federal support for education in the name of science has been a great source of public enlightenment and has opened the way for understanding of the positive and important contributions Federal support can make to education in general without impairing any of the cherished traditional prerogatives. Our reward will be a better intellectual and scholarly climate in the country as a whole, a climate in which science itself can flourish even more.

Challenges for the Future

In examining some of the important developments in the lifetime of the Foundation to date, it becomes clear that significant changes in circumstances have taken place to which current and future activities must be responsive. New problems have appeared with the passage of time, and I would like to touch on a few of the matters which seem to me to be deserving of special consideration in the immediate future.

No drastic adjustment is necessary for the Foundation to fit itself comfortably into the altered climate and probable changes in the pattern and direction of support of science and science education. Because of the breadth and flexibility of its legislative mandate, the Foundation is equipped, within limits, to lend its support to research and education for the dual purpose of promoting scientific productivity and providing an opportunity for increased cultural and intellectual development for larger numbers of people. At the same time Foundation activities can both foster and shelter the image of science as a field of intellectual activity that is worthwhile for its own sake.

For this reason, I believe that the Foundation should be regarded, and should think of itself, as the repository of Federal recognition of science as a national resource—a continuously renewable resource that is vital to the national interest. In addition, the Foundation should be the champion and the protector of basic research—the fountainhead of new ideas and the area most likely to suffer in a period of economic retooling of support.

This is not intended to mean that the Foundation can, or should, assume the function of compensating for every change in the pace of support provided by other Federal agencies, nor should it assume the responsibility for doing all the things that others are disinclined to do. On the contrary, with the assistance of the scientific community, the Foundation should assess the total needs, and take advantage of support provided by all other Federal agencies by building upon it when appropriate, and to the extent of available capacity, in order to fulfill total needs as completely as possible. In the exercise of such leadership and in providing a voice for science within the Federal Government the Foundation can make a most significant contribution to the health of basic research as a component of total national strength.

Need for Increased Support of Research

Recent statistics compiled by the National Science Foundation point to a leveling-off of support for basic research by several of the major Federal agencies. Appearance of this trend raises a question as to the future role of the Foundation in the presence of the widespread belief that Federal support for basic research in our colleges and universities must be progressively increased in the years immediately ahead merely to maintain our present relative position in science while sustaining the pace of technological development.

The need for increased Federal support for basic research can be associated with three causes. First, many first-rate scientists do not now receive a degree of support sufficient to enable them to develop fullest effectiveness, to the detriment of the national scientific capacity. Second, support must be provided for increasing numbers of faculty members and graduate students engaged in research as academic institutions expand their enrollments to meet the needs of the growing college-age population. It is estimated that this increase will be in the order of about ten percent annually for many years to come.

Finally, the inescapable fact must be faced that the cost of research continues to rise. Research becomes more complicated, calling for more sophisticated equipment, and the estimated increased cost per investigator has been placed at about 5 to 7 percent annually. These two estimates combined produce the apparent need for an annual increase of 15 percent or more in support for basic research at academic institutions. Obviously the figure of 15 percent is imprecise, but the problem of determining the appropriate level of basic research support, particularly in the universities, is a matter which is being given serious study by the Foundation and other groups—notably a special panel of the President's Science Advisory Committee.

Regardless of changing requirements, I believe that the pattern of Federal support should endeavor to sustain the high quality of research activity now identified with outstanding individuals and institutions and contribute to its enhancement where possible. Quality has no ceiling, and its existence invites challenge and competition, as well as emulation. Such institutions are important national assets, because they are the leading sources of scientific progress, and because their graduates constitute the vital force which energizes the entire national scientific structure.

At the same time I believe the national interests can be served and the base of overall scientific capability broadened by providing assistance to graduate institutions now possessing acknowledged competence in research and education along with a demonstrable potential for effecting significant qualitative improvement. Special efforts are required if these promising institutions are to make an optimum contribution to the total national capability for science and technology.

In addition to continued support for research for recognized scientists, it is my view that research funds should be made available to promising younger members of science and engineering faculties who have not yet achieved reputations, and whose chances of attracting Federal research support under the criteria applying to established senior scientists are understandably small. This group constitutes a research potential worthy of cultivation and encouragement, and which indeed the country can ill afford to ignore. Moreover, the roles of research and education are so interrelated that modest investments of research funds in such men would, at the same time, yield returns in terms of better educational opportunities

for the student bodies at the institutions where these younger scientists are located. This is an area that is under continuing study by the staff of the Foundation.

Problems of Undergraduate Science Education

The National Science Foundation has long been active in undergraduate and especially pre-college education in the sciences. The trends of the times call for more intensive and extensive Federal support in these areas—bearing in mind the need for greater equality of opportunity for the individual students.

There is much that needs to be done to improve undergraduate science teaching. However, I hold little or no brief for the allegation that Federal support of research, although enhancing graduate education, has detracted seriously from undergraduate teaching. There have been expressions of concern in recent months that some of our major universities have become giant research factories concentrating on Federally-sponsored projects to the detriment of their educational function. In my view, this is a seriously exaggerated assessment of the situation.

The good teacher must be a scholar, and research is an important form of scholarship—though by no means the only one. The good teacher must be alive to his field; he must keep up with its contemporary advances, and no better mechanism for this exists than to be actively contributing to advances. The time spent on research and on graduate and other advanced students may not permit every faculty member to devote a substantial amount of attention to students in introductory courses. But this is not a new phenomenon. Some time ago a young chemistry student remarked: "You cannot imagine what a crowd of people come to these lectures. The room is immense, and always quite full. We have to be there half an hour before the time to get a good place, as you would in a theater; there is also a great deal of applause; there are always six or seven hundred people." The quotation is taken from a letter written by Louis Pasteur about a hundred and twenty-five years ago in which he describes the chemistry lectures he attended at the Sorbonne. Large lecture courses are of course traditional in many European universities, but they are by no means a recent development in higher education in this country.

The simple fact is that we have many more outstanding scientists and engineers in our colleges and universities today than we did a generation or two ago. Today's freshman student at a major university may find it harder than it was in his father's student days to meet and talk with the "most outstanding chemist" on the campus—but today, instead of a single chemist overshadowing all others, there are likely to be half a dozen of outstanding competence. Student bodies, on the other hand, have also multiplied, making personal, individual communication difficult.

Serious study of this situation by a number of institutions has been going on as a result of some of the recent expressions of concern—and such self-examination may lead to the discovery of better ways of assuring appropriate lines of communication between undergraduates and professors. But the President of one of our major institutions, in assessing the findings of a study on this problem that he has recently completed, stresses that (in this as in many other nostalgic views of the past) those who are criticizing the present situation are sometimes prone to remember only the best of the past. His conclusion is that the level of undergraduate instruction on his campus has improved rather than deteriorated as a result of the burgeoning research program at that institution in the past few decades.

However, I do not feel that the increasingly severe criticism of the impact of research on teaching can be completely shrugged off. Nor do I feel any sense of complacency about the status of undergraduate science education in our academic institutions as a whole.

Many people feel that, especially in some of the larger institutions, introductory science courses are viewed as elimination contests, a method for "separating the men from the boys" before the former get on with the serious business of pursuing careers in science. Perhaps more thought given to presentation of subject matter in such a way as to inspire interest and to give the student a better opportunity to appreciate its deeper meanings would improve the progress of those equipped and motivated to persevere in science and would also prove useful in the more general sense to those who cannot or do not wish to pursue careers in science.

In any case there is much room for improvement in undergraduate science curricula in most of our institutions. Especially in the 4-year colleges there is a serious problem of recruiting and retaining science faculty members of real competence and enabling them to keep pace with the progress of science.

The Foundation has several modest programs to assist in improving undergraduate education. Among these are curriculum improvement projects, science faculty fellowships, undergraduate research participation programs, summer institutes for college teachers, faculty exchange relationships, and others. But these programs are all modest in size, and can provide only correspondingly modest amounts of help in dealing with a problem which is of nationwide and massive scale. The Foundation has the legislative authority to deal more fully with some of these problems, and it is my intention to push forward in the development of ideas and mechanisms which will be recognized as appropriate for implementation by the Foundation. In doing so, we shall work closely with the Office of Education, to make sure that our efforts and theirs are complementary rather than competitive, mutually reinforcing rather than duplicating. The continuing close relationships between these two agencies give me reason to believe that we will have no dif-

ficulty in finding areas of operation where the specialized experience and competence of the National Science Foundation can be used to augment with good effect the broader, "education-wide" activities of the Office of Education.

Interdisciplinary Approach to National Problems

A continuing issue—one that can only be attacked and never disposed of—is that of using the methods and findings of the pure and applied sciences to help deal with pressing social problems of an increasingly complex society. In general, the major problems which loom large before the Nation are almost all related in one way or another to science and technology. But there is rarely a social problem which is the exclusive concern of a single scientific discipline, in the traditional sense of the term. Many problems can be dealt with in part by chemistry, or in part by other fields within the physical sciences; some problems clearly require the attention of engineers and social scientists; still others cannot be solved without the aid of life scientists and physical scientists.

Whether one thinks of the need for improved systems of transportation, better conditions of urban life, cleaner (which is to say less polluted) waterways, or lower rates of juvenile delinquency, science and technology must be thought of as constituting one of the major resources available to those who must cope with these problems. "Science and technology" in this case means broad, multidisciplinary ranges of expertise rather than the narrower concept of specialization which has so long characterized our image of the constituent entities of the scientific enterprise.

This trend toward broad treatment of *scientific* problems has been with us for some time. Mathematicians and physicists have teamed up repeatedly to probe into questions having a mutuality of interest. In many advanced areas today the distinction between chemistry and biology has almost disappeared, and the interdisciplinary approach is now commonplace in a large number of other areas. Thus bridges have been built between distinctive disciplines of the physical sciences, and between the physical and life sciences. There are still far too few such bridges connecting the natural sciences, engineering and the social sciences, although links between these broad domains are becoming somewhat less rare.

The National Science Foundation, along with all Federal agencies concerned with scientific and technical matters, must try to devise more effective ways of facilitating and encouraging partnerships of effort between engineers, natural scientists, and social scientists—partnerships which will increasingly be required if we are to find, without undue delay, adequate solutions to our urgent social problems. I realize that the difficulties inherent in this task are great, and obviously the Foundation cannot hope to accomplish more than a fraction of what needs to be done. But it is my conviction that the

Foundation has a role to play in this area, and we will be examining continuously the ways in which Foundation activities in support of research, science education, and resource studies can be more helpful in this regard. New approaches to the fulfillment or our responsibilities along these lines may require an examination of the current organizational structure of the Foundation, and if such an examination reveals the need to create new "system-oriented" units, we stand ready to bring such units into being as promptly as possible.

A major factor relating to this interdisciplinary approach to substantive areas of national concern revolves on the problem of disseminating scientific information as promptly and widely as possible. Much has been done to improve the various mechanisms that have been devised for this purpose, and the Foundation has played a growing role in this regard through its Office of Science Information Service. However, we feel that our responsibility in this field is a broader one, and it is our intent to seek out additional ways by which the Foundation can help to improve the dialog between those engaged in uncovering scientific knowledge and those in industry, government, and elsewhere who have need of such knowledge in solving practical problems.

Whether this will take the form of special conferences, working groups drawn from each of the relevant sectors, or special studies undertaken by staff or consultants—or still other possible approaches—I cannot say at this time. We are hopeful that through such mechanisms we will be able to carry out our responsibilities in this area more fully.

In reviewing the work of the Foundation over its lifetime of 15 years it is clear that much of what has been accomplished can be attributed in large measure to the harmonious relationship developed between the Foundation and the scientific community. One of the factors contributing to this is the position of the Foundation that the scientists of the nation are best equipped to determine what is in the best interests of science. Over the years there has grown up an interdependence between the Government and our colleges and universities, an interdependence which thrives best when the requests Government makes of educational institutions are consistent with the institution's inherent goals.

Whether Government support is proffered in support of research or science education, it is the conviction of the Foundation that such support should be as direct as possible, and encumbered only with the minimum of administrative restriction necessary to satisfy the normal requirements of sound fiscal management. Good intentions can too readily be frustrated and rapport undermined by excessive emphasis on restrictions and restraints which may tend to inhibit the intellectual flexibility of academic institutions.

The Nation clearly benefits as a result of Government support which strengthens our colleges and universities, but the benefits can be adulterated if excessive time and energy must be diverted into avenues not closely and

directly related to the development of scientific or educational potential. This concern weighs heavily in Foundation planning, and policy favors the less constraining techniques of support in so far as possible.

As we look to the years ahead, the Foundation recognizes additional areas of opportunity which now invite exploration. While the picture of the past is satisfying, the years ahead will be years of increasing fulfillment. We must foster and encourage the evolutionary process by which the Foundation has grown, for science is indeed an endless frontier, and we must adapt ourselves to its ever-changing pattern in meeting the continuing challenge.

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