DIRECTOR'S STATEMENT

In previous years the "Director's Statement" in the Annual Report of the National Science Foundation has combined a summary of some of the more outstanding events of the year with discussions on such general topics as Federal support of research and development, the Foundation's history, objectives, organization and programs and so forth. In this, the Seventeenth Annual Report, covering fiscal year 1967, an introductory chapter serves to summarize and highlight the year's activities in considerably more detail than have the Director's Statements of the past. Hence, this Statement will be restricted to a brief discussion of some of the broader issues facing the Foundation and the Federal Government as a whole with respect to science.

On July 5, 1945, Dr. Vannevar Bush, then Director of the Office of Scientific Research and Development, sent to the President his famous report on a program for postwar scientific research entitled "Science, The Endless Frontier." In his transmittal letter he stated:

> The pioneer spirit is still vigorous within this Nation. Science offers a largely unexplored hinterland for the pioneer who has the tools for his task. The rewards of such exploration both for the Nation and the individual are great. Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.

In the 22 years since Dr. Bush's report, the exploration of the "hinterland" of science has gone forward with unprecedented intensity. New, sometimes unexpected, regions of understanding have been opened up and valuable, sometimes priceless, findings have been made. At the same time, our general capabilities for scientific exploration have also increased substantially. Physical facilities and instrumentation measure what was previously unmeasurable and analyze and communicate information as never before.

Increasingly our era is one in which new ideas and ways crowd one on the other; concepts and methods change quickly and are old before their time; our society and personal lives are tremendously affected by the impact of science and technology—overwhelmingly for betterment even though some aspects of their applications have had undesirable side effects. And yet, in spite of such profound change, the above quotation is as true today as when it was written. The "unexplored hinterland" and

the material and cultural rewards it offers will always be there—only our perception and the extent of exploration change with time.

In this country particularly, science is flourishing in an unprecedented way—one that is unequaled elsewhere in the world. American scientists are at or near the vanguard in all areas of science and the fruits of their research have had great impact upon our rapidly developing technology. The nation's commitment to science and technology is well demonstrated by the fact that from 1953 to 1966—the earliest and latest years for which accurate figures are available—the annual, national investment in research and development more than quadrupled, whereas the Gross National Product only doubled. Investments for research and those for development have increased in approximately equal proportions but, significantly, the relative emphasis on the basic component of research has increased most substantially, its financial support having increased sixfold during the 13-year interval.

Fortunately, the growth of scientific manpower has kept pace with the nation's demands. The proportion of scientists and engineers in the total civilian labor force has never been greater. In 1954, approximately 370 of every 100,000 civilian employees were research and development scientists and engineers. Today, this proportion has approximately doubled. In the universities, in industry and in Government far more people with, or working toward, advanced scientific or engineering degrees are engaged in research and development, with greater individual productivity and with more financial support than ever before.

In all of this the impact of Federal investments has been enormous. Partly to meet its own specific needs and partly in the general public interest, the Government has increased its expenditures for science and its applications by leaps and bounds so that today Federal support for research and development represents nearly two-thirds of the total national investment in these activities. As in the total national case, greatest increased emphasis has been on basic research, as evidenced by the fact that in the past 10 years the Government's support for it has increased from approximately 7 percent to 15 percent of total Federal R. & D. expenditures and has increased from less than half to about two-thirds of the total national investment in such research.

Nowhere has the impact of the Federal commitment to science been greater than in the country's academic institutions. From essentially none before World War II (except in agriculture), Federal support for the conduct of research in the academic institutions proper (as distinguished from federally owned "contract research centers" operated by the universities) rose to approximately $1.26 billion in fiscal year 1966, almost two-thirds of the total research expenditures in those institutions; additional funds of the order of $0.11 billion were obligated for research laboratories and research facilities. Although the primary objective of most of this support has been to meet the informational needs of the agencies

having specific missions—in defense, health, space, atomic energy, etc.—it has, nevertheless, had a profound impact on education, especially at the graduate level where the conduct of research is vital.

In recent years significant, though smaller, support has also been given to higher education in its own name. Students have been assisted through fellowships and traineeships (as well as through opportunities for employment on research projects); growing support has been given to the classroom teaching function, especially by the National Science Foundation and, at a rapidly increasing rate, by the Office of Education. Still another type of program in several agencies provides special support to assist selected institutions to improve the quality of both research and classroom activities. In total about $2.2 billion was obligated by the Federal Government in fiscal year 1966 for support of research and science education in our universities and colleges.

Unfortunately, the many demands upon the Federal Government's financial resources have recently forced a leveling off in its total support for science. This has inevitably given rise to problems, some new, some merely brought to sharper focus. The rate of acquiring new knowledge will inevitably be slower than it would otherwise have been; certain opportunities for new advances requiring costly equipment will have to be postponed; the needs of higher education will not all be met. I wish to discuss, however, only one aspect of the total problem, namely, Federal support of graduate education in the sciences and engineering.

It is almost universally recognized that one of the most valuable things an individual can strive for, both from his own point of view and from that of society, is a good education—scientific or otherwise. A well-educated individual is better able to adapt to his rapidly changing environment; to be a productive member of society with a higher economic status; and to have a broader range of choices which will add to his enjoyment of life. Our society needs educated citizens for an effective democracy and a vigorous economy; such citizens can participate more actively and effectively in the life of their community and that of the Nation. Also, it has been estimated that "the additional schooling of the labor force would appear to account for about one-fifth of the rise in real national income in the United States." [1] Hence, resources invested in education benefit both society as a whole and the recipients as individuals—in keeping with the very essence of democracy.

This belief is attested to by the fact that the Nation's investment in education at all levels has grown by leaps and bounds and that school and college enrollments, especially the latter, have grown far faster than have the school and college-age populations. Enrollments in colleges and universities have quadrupled since 1940—indeed have doubled in the

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[1] T. W. Schultz, *The Economic Value of Education* (N.Y.: Columbia University Press, 1963) p. 11.

past 10 years. Out of a given number of college-age young people four are now enrolled in college for every three who would have been in 1957.

Not so universally recognized is the crucial nature of the role played by graduate education. The leaders in research—be it in science or in other fields—be it in the universities, in industry or in Government—are predominantly found among those educated to the highest levels. Among these highly educated individuals are those who train the research leaders of the future, and who teach our undergraduates for all walks of life, including that of teaching in the Nation's schools. Thus, the process of graduate education is essential to our progress in every aspect of modern life.

Fortunately, the desirability of a graduate education has been increasingly recognized by the Nation's youth. Total graduate enrollments have doubled since 1960 and are expected to do so again by 1980. Although science and engineering account for only about one-third of the total of such enrollments, approximately two-thirds of the Ph. D.'s are awarded in these fields. This seems to result from two factors. First is the widespread and increasing awareness on the part of industry and the public of the tremendous economic and social benefits which can be derived from the applications of science and technology. This has created a corresponding increase in demand for highly trained personnel which is reflected in the desire of students to acquire training that will qualify them for the new employment opportunities. A second factor is the startling increase in the quality and complexity of scientific and technological knowledge itself. This, in turn, has generated a situation in many areas of science and technology where a student usually cannot acquire the training needed to qualify him for independent professional activity without advanced graduate training. This trend toward acquiring more advanced training is currently most pronounced in engineering, where in recent years the doctorate production has increased at a substantially greater relative rate than in the sciences proper.

There is no question that the recipients of a graduate education will be usefully employed. There is every indication that industry will need ever-increasing numbers of personnel who are highly trained in the sciences and engineering; the colleges and universities will clearly do so in view of their increasing enrollments. Furthermore, in addition to the need for growing numbers of scientific and technical personnel, there is an equal need in all sectors that they be more highly educated. For example, the fraction of the individuals on the faculties of the Nation's universities and colleges who possess the Ph. D. or equivalent degree has always been much lower than desirable. Moreover, although the rate of granting this degree has increased rapidly (doubling since 1960), the growth of undergraduate enrollments and hence of academic faculties has been so great in recent years that the fraction of the faculty possessing Ph. D.'s has, unfortunately, declined from a peak of roughly half in the

early 1960's to an estimated 35 to 40 percent at present.[2] Although, assuming past career choice patterns, the fraction of the academic faculties who hold the Ph. D. will shortly start to rise again, it is not expected to reach the 50 percent mark of the early 1960's until at least midway of the 1970's. This shortage of the most highly qualified individuals has, of course, been more seriously felt in the developing than in the well-established universities, still more seriously in the four-year colleges, and most seriously of all in the rapidly burgeoning junior colleges.

An especially acute need, perhaps even more acute in its way than the total national need, is that of regions, States and localities that are endeavoring to develop high-quality academic institutions where such do not now exist. It is generally recognized that a first-class university or, to a more modest extent, a first-class college, has a highly salutory effect on the total life of the locality in which it finds itself. It influences in a positive way the educational systems, the culture, the intellectual life and, in more or less degree depending on the circumstances, the overall economy. Quite apart from the financial support they may receive, institutions endeavoring to better themselves and hence their communities have great difficulty in doing so when there is a shortage of high-quality individuals with whom to build their faculties. In the face of such a shortage they find it hard, if not impossible, to compete for such individuals with those institutions already recognized as having high quality.

The need for higher levels of training of their personnel is also present in industry and in Government laboratories as well as in the universities and colleges. Not only must new personnel be more highly educated but also there is great, and proper, demand on the part of working scientists and engineers for opportunities to extend and update their knowledge by returning to the universities as full- or part-time graduate students.

Thus, from every standpoint—national, local, and individual—it is highly desirable that the growth of graduate education—both quantitative and qualitative—should continue. This is part and parcel of the enlargement of our national objectives in education. As a nation we are asking our educational system to do more than turn out a greater number of graduates. We are asking our colleges and universities to produce better educated graduates and we want them to come from a larger number of universities and colleges. It is in the national interest that such institutions be present in every region of the land, including every large metropolitan center, and that we give added encouragement to those disciplines that have most direct relevance to our physical and social environments so that the creative and fresh thinking of young graduates can contribute to problems concerning the general welfare.

Unfortunately, the costs are sobering. With the extremely rapid growth of enrollments the colleges and universities have found themselves ex-

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[2] The relative rate of increase in the already large pool of Ph. D.'s is, of course, much lower than the rate of increase in newly available Ph. D.'s.

tremely hard pressed to meet the costs of their undergraduate programs, despite sharply increased tuition fees, especially in private institutions. The graduate institutions are for the most part already at or near present capacity and the cost of developing the facilities and equipment and employing the faculty and others needed to meet the increased enrollments over the next 10 years poses a grave problem to the institutions themselves and to their public and private supporters. The increasing complexity, and therefore costliness, of science adds another factor to the difficulty. Although it would be desirable in the future for the States and local communities to assume a larger fraction of the cost of graduate education, including the research that constitutes so large a portion of it, it seems unlikely that this will be possible at least for some years to come. They will do well to maintain their present proportion in the face of rising enrollments and rising unit costs. In a direct way, therefore, the rate of growth and quality of academic research and graduate education depend on Federal support. It is highly appropriate that this support be forthcoming because, of all levels of education, the graduate level is the most national in character; graduate students at the various universities come from all regions of the land and, after graduation, disperse to every quarter. Furthermore, the Government's own programs are heavily dependent on an adequate flow of the most highly trained personnel.

Graduate education has benefited greatly from the happy circumstance that funds expended for research directly serve the cause of education, whatever the motive for making the investment. Thus, research support provided to the universities by Federal agencies in pursuance of their missions serves the cause of graduate education, even when that is not the primary aim. Indeed, a majority, and until recently a very large majority, of the Federal support for graduate education has resulted from this circumstance. But, especially in the face of ever-increasing needs for graduate education, there is inherent in this situation a potential for difficulties arising from the fact that the research requirements of the various agencies pursuing specific missions do not necessarily coincide, either in quantity or in kind, with the needs of the universities for support of graduate education. For example, there is no inherent reason why the overall need of a given agency for new scientific knowledge should grow at as great a rate as the graduate population. Nor is it inherent that the combined agencies' need for knowledge in any given field will keep pace with the Nation's overall need for new knowledge in, or new scientists trained in, that particular field. Fortunately, these circumstances have not given rise to serious problems in the past, since the overall needs of the combined agencies have kept pace with the growth in graduate education. The plurality of support and the potentiality of balancing adjustments by the National Science Foundation and to a lesser relative degree by others have largely met the needs. However, the recent leveling off in the

Federal Government's support for academic research during a period of increasing enrollments and rising costs has brought about a problem.

It, therefore, seems clear that the policies and programs that worked so well for graduate education in the past should have a reassessment. It seems almost certain that the inevitable increases in Federal support of universities in the years to come should have an appreciably larger fraction directed at graduate education in its own right. In part this could be accomplished by increasing support in categories of costs already supported apart from research awards—e.g., relatively more fellowships and traineeships; larger cost of education allowances in connection with fellows and trainees; greater support for new facilities such as buildings, instructional equipment and computers for educational use as well as for research. In part it could entail supporting directly some categories of costs for which assistance is now given only through research awards, but which are present regardless of the nature and scale of particular research projects—e.g., partial support for faculty salaries; equipment for general use; at least a substantial portion of those indirect costs now supported through research, etc. The research projects themselves would still support those costs directly attributable to the specific research—e.g., faculty salaries in special cases, salaries and wages of other professional and nonprofessional personnel, specific items of equipment and supplies, travel associated with research, cost of publication of research results and so forth. To take such steps would free the universities from a large part of the uncertainties inherent in the inevitable ups and downs of research project support, while still retaining the great virtue of selectivity on a quality basis of the research to be supported by the various agencies. The greater flexibility permitted would also enable the universities to provide more adequately for the research needs of the younger members of their faculties who have not yet acquired sufficient experience and recognition to enable them to succeed in receiving Federal research awards in competition with their seniors.

Such a transition could obviously not be accomplished overnight; indeed, to avoid undue disruption it should probably be done incrementally as increasing funds are made available for the support of the entire graduate research and education enterprise.

In recognition of the desirability of some such reassessment as that alluded to above, the National Science Board has established a special committee—comprised in part of members, in part of experienced and knowledgeable outside individuals—which, with assistance from the Foundation staff, is studying the opportunities and needs of graduate education in the sciences and engineering with the aim of recommending policies and programs for the long-range future. The conclusions and recommendations of this study, as modified by the Board itself, will result in a Board report to be issued some time in 1968.