V. ANALYSIS OF BUDGET FUNCTIONS

1. Research Policy Development, and Services

Summary of Financial Requirements. The funds requested for this activity are for the following purposes:

Development of a national science policy	$ 50,000
Dissemination of scientific information	285,000
Maintenance of the National Scientific Register	156,000
Support of the Interdepartmental Committee on Scientific Research and Development	26,000
Operating costs of the Foundation	268,000
Total	$ 785,000

Development of a National Science Policy. The National Science Foundation Act, in section 3(a) (1), authorizes and directs the National Science Foundation "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences." As already indicated, the Foundation regards this function as a primary responsibility. Such a policy must be compounded of many ingredients. It must draw on the thinking of a wide variety of leaders in the scientific disciplines and of outstanding laymen whose experience has given them knowledge and understanding of scientific research. Much of the planning of a national science policy will be done by the members of the National Science Board and the staff of the Foundation. To supplement the Board and the staff, the Foundation is authorized to establish special commissions to make comprehensive surveys of research, both public and private, recommending to the Foundation an over-all research program in the field of the survey. It is expected that at least two such commissions will be appointed and commence deliberations in the coming fiscal year. Finally, the advice and comment of organized scientific groups including professional societies and conferences and the published thinking of individuals must be considered and utilized where pertinent.

Although a national science policy must stem from many sources and embody the contributions of diverse groups and individuals, the policy must, if it is to be sound, rest on a firm foundation of fact. Developing such a body of fact is one of the chief responsibilities of the Foundation. Much of the fact-gathering and fact-analysis can be supplied by the Foundation's own staff. But it is practically certain that the Foundation's staff, because of its limited numbers, will be unable to provide all the information and analysis which will be required. Its efforts will need to be supplemented by studies conducted by groups outside the Foundation having specialized staffs or skills. It is estimated that $50,000 will be required for this purpose in fiscal year 1952.

Dissemination of scientific information. By section 3(a)(5) of the National Science Foundation Act, the Foundation is authorized and directed "to foster the interchange of scientific information among scientists in the United States and foreign countries" and in section 13(a) to "defray the expenses of representatives of Government agencies and other organizations and of individual scientists to accredited international scientific congresses and meetings." The nerve system of a healthy and vigorous scientific effort lies in ready exchange of information. Scientific progress is cumulative. One individual builds on the findings of other individuals or groups; in turn his work becomes modified or augmented by still other individuals. The faster and more easily information passes from scientist to scientist, the faster science progresses. When this intellectual exchange is hampered or slowed, science as a whole declines.

Serious problems exist in the dissemination of scientific information both internally in the United States and in obtaining for scientists in the United States the benefit of scientific information developed in foreign countries. Publication of scientific papers in the recognized journals is now subject to delays of as much as several years. Technical difficulties in abstracting published articles and in distributing abstracts among scientists further delay the proper correlation of research activities throughout the world.

Efficient dissemination of scientific information not only stimulates scientific progress, it is also a guarantee against wasted effort. A scientist will not knowingly undertake an investigation which has previously been adequately covered. The professional standing of a scientist depends upon his capacity for sound and original work. He jeopardizes that standing whenever he undertakes research which has previously been adequately covered. Thus, by all odds the most effective insurance against undesirable duplication and overlap in research effort is a free flow of information among working scientists.

Information is exchanged among scientists largely by two means, publication of scientific findings and by personal exchange of information, especially at scientific meetings. As a part of its program for 1952, the Foundation proposes to take modest steps toward improving the functioning of both of these means.

With respect to the publication of information, the need is two-fold, (1) to insure that all worthwhile findings are published in an economical manner and (2) to develop techniques by which published materials can readily be made available in usable form to scientists as needed.

In 1952 the Foundation's efforts toward insuring comprehensive publication will consist largely of studies by the Foundation's staff. In these studies, an analysis will be made of the broad phases of scientific literature in the United States to determine (1) in which areas publication facilities are lacking or inadequate, (2) where gaps exist in the major collections of scientific literature and what can be done to close these gaps, and (3) the factors which contribute to a lag in publication of research results.

To develop new techniques for the quick and economical dissemination of scientific information, the Foundation also will sponsor research in this field. This research will be designed to produce improvements in (1) existing methods of abstracting information, (2) the use of mechanical means for compiling bibliographies and other reference materials, (3) more rapid ways of preparing and processing units of scientific literature, and (4) methods for indicating the availability of these units of scientific literature. For these purposes the amount of $225,000 is included in this estimate.

The second principal means by which scientific information is exchanged is through meetings. U. S. scientists must have access not only to the published findings of scientists abroad but also on occasion to these scientists themselves. Personal contacts stimulate thinking in a way which printed publications cannot. The attendance of American scientists at such recent meetings as those of the International Physiological Congress at Copenhagen, the International Biochemical Congress at Cambridge, the International Nuclear Physics Symposium in Zurich has resulted in bringing back to the United States information which has saved American scientific research many times the actual cost of travel. The Foundation's estimate includes $60,000 for this purpose; this will provide for the attendance of 60-80 scientists.

Maintenance of the National Scientific Register. In section 3(a)(8), the National Science Foundation Act authorizes and directs the Foundation "to maintain a register of scientific and technical personnel and in other ways provide a clearinghouse for information covering all scientific and technical personnel in the United States, including its territories and possessions."

Trained technical manpower is one of our national resources. In formulating a national policy for science and in planning for mobilization of scientific effort in time of war, comprehensive information on scientific manpower is essential. The need for information of this kind became apparent early in the last war and was met by the establishment of a national roster of scientific personnel. The usefulness of this roster during the war in locating scarce skills and providing other information on scientific personnel was demonstrated. After the war, its continuation on a limited basis was undertaken by the National Research Council with the support of the Office of Naval Research, the Veterans Administration, and other Federal agencies.

In 1949, the National Security Resources Board concluded that the establishment of the roster on a broad basis was essential to our mobilization readiness. Legislation then being considered by the Congress would have assigned this function to the proposed National Science Foundation. Pending the passage of the National Science Foundation Act, the Office of Education undertook, beginning in the spring of 1950, to activate and administer a National Scientific Register on an interim basis with funds transferred by the National Security Resources Board. In accordance with section 14(i) of the National Science Foundation Act, the Foundation will assume direct operation of the Register sometime in fiscal 1952. It plans to provide financial support by a transfer of funds to the Office of Education for the period during which it will remain under that Office's administration.

The activities of the Register fall into three groups: (1) initial compilation, (2) maintenance, and (3) research studies of the "registered" population and on techniques of quickly disseminating information concerning registrants to potential users.

The Register to date has concentrated almost wholly on the first activity, compilation. This consists of circularization of a questionnaire to scientists, coding of returned questionnaires, reduction of the coded information to machine tabulating cards, and abstracting experience for use in dissemination of information about registrants.

Compilation is now one-third completed. The Register is expected to total approximately 300,000 names when completed.

During fiscal year 1952, the Register's work plans are: (1) to continue the registration of scientists and analysis of their experience, (2) to establish procedures for maintenance of the Register after completion, (3) to prepare and publish statistical studies of the personnel included in the Register, and (4) to develop and maintain a clearinghouse of information on scientific personnel for use of agencies of the Government and other activities.

The financial history of the Register and its requirements for fiscal year 1952 are as follows:

Funds originally transferred to the Office of Education by NSRB in fiscal year 1950.......		$279,400
Less amount obligated in fiscal year 1950.....		10,600
Amount available as of July 1, 1950...........		$268,800
Estimated obligations in fiscal year 1951:		
Staff costs.............	$. 93,800	
Contractual costs (for mailing, coding and tabulating questionnaires)................	160,000	253,800
Estimated unobligated balance as of July 1, 1951................................		15,000
Funds included in this estimate:		
For transfer to Office of Education..........	156,000	
Included in operating costs of the Foundation	14,000	170,000
Funds available for fiscal year 1952................................		185,000
Estimated obligations for fiscal year 1952:		
Staff costs.............	95,000	
Contractual costs:		
For completion of Register............	70,000	
Research studies......	20,000	185,000
Estimated unobligated balance as of June 30, 1951		-0-

Support of the Interdepartmental Committee on Scientific Research and Development. By Executive Order 9912 of December 24, 1947, the President, acting on a recommendation of the

President's Scientific Research Board, established an Interdepartmental Committee on Scientific Research and Development. The Committee is composed of representatives of the agencies of the Government directly concerned with research activities: the Departments of Agriculture, Commerce, Defense, Interior and State; the Army, Navy, and Air Force; the Federal Security Agency; the Atomic Energy Commission, the National Advisory Committee on Aeronautics; the Veterans Administration; and the Smithsonian Institution. It is expected that the President will shortly authorize membership by the National Science Foundation. The principal functions of the Committee are continuing review of administrative policies and techniques to increase the efficiency of scientific operations within the Government and encouraging cooperation among the scientists of the Government agencies.

Members of the Committee and of its subcommittees and panels serve on a part-time basis. The Committee also has a full-time secretariat. Following the pattern established in the 1951 budget, the Foundation's estimate for fiscal year 1952 includes $26,000 to cover the salaries of this secretariat. These funds will be transferred to the agency which provides physical housing for the Committee's secretariat and whose representative is Chairman of the Committee. In fiscal year 1952 this will be the National Advisory Committee on Aeronautics.

Although the Foundation will provide financial support for the Committee, it is not anticipated that the Committee's present function or relationships with Federal research activities will be altered as a result.

2. Research Support

Summary. Funds requested for this function are for the purpose of providing support in the form of grants, contracts and other arrangements for basic research in the sciences distributed among the major classifications as follows:

Medical sciences.................	$1,300,000
Biological sciences..............	2,600,000
Mathematical, physical and engineering sciences...........	3,913,000
Operating costs..................	342,000
Total	$8,155,000

Importance of Basic Research. The National Science Foundation Act of 1950, in Section 3(a)(2), authorizes and directs the Foundation "to initiate and support basic scientific research in the mathematical, physical, medical, biological, engineering and other sciences ... and to appraise the impact of research upon industrial development and upon the general welfare."

The leading economic, industrial, and military position of the United States is due in large part to the technological ability of the American people. Our real genius as a Nation has been the power to convert scientific knowledge into practical utility. Evidence of this is found on every hand, in industry, in business, in public health, and, during two World Wars, in our military power. It is fundamental to our high standard of living.

By and large, however, it is only recently that the country has come to recognize that technological advances are made possible only through the application of fundamental scientific knowledge already known. This fundamental knowledge has been a heritage available to us from the accumulated findings of science all over the world. We drew heavily upon this stockpile during the war, very seriously depleting it. Since research has very nearly come to a standstill in most other countries, the replenishment of this stockpile now rests chiefly in our own hands. Certainly, among the Western nations the responsibility is ours, and it is indeed a grave one.

Until comparatively recently and except in a few outstanding cases, we have not in the past led other nations in fundamental research. We have now come to realize that, if we are to maintain the leadership in technology necessary to our welfare and security, we must ourselves produce the major portion of the necessary knowledge basic to scientific progress. Indeed, during the present emergency this may be the price of survival.

The importance of basic research is demonstrated by the fact that many of the major original discoveries in science, for example, the electric current, the X-ray, and vaccination, had their origin in the research of gifted individuals whose only aim was to learn the secrets of nature. Yet major discoveries like these have made world-shaking changes in our civilization and their dollar value is beyond estimation. They represent a reservoir of power and wealth. Atomic energy technology, with all of its implications for our military and economic life, had its origin in basic research fifty-five years ago with the discovery of radioactivity. For the first forty-four years its study was confined entirely to scholars and basic research investigators and it provided no practical applications except for the use of radium in cancer treatment and in luminous watch dials. Ultimately, the accumulated background of experimental and theoretical investigation, and improvement in laboratory techniques, made possible the discovery of atomic fission. This led directly within the next six years to a development so important and far-reaching that we have hardly as yet been able to see its potentialities.

In its relation to the present emergency the problem of planning and supporting basic research and science should be viewed as follows: Since both the degree and the duration of this emergency are uncertain, it is clear that we must (a) with all dispatch, put ourselves into what the military call "operational readiness" and (b) take the necessary steps to maintain ourselves in this state of readiness for an extended period, perhaps for many years. This we should do with the realization that at any time the emergency may turn into a crisis. In its application to science, this means that scientists should play their part immediately in seeing that urgent military applications of science should be expedited, where these are capable of being put to practice in a short period, say two or three years. Obviously this should be done with all the care that can be spent on an emergency problem. We know that the country certainly cannot undertake all possible scientific applications in a limited period and hope to complete them in time for operational use. Therefore, there must be careful selection as to the practical developments which are both feasible and of high priority.

In order to maintain our scientific readiness over a long period of years, we must also do our utmost to strengthen our scientific progress and maintain that strength at the highest possible level. In this second phase, to maintain scientific progress at a maximum level, it is essential that we keep the initiative, scientifically speaking, in as direct a sense as we keep the initiative with respect to the effectiveness of our military forces. It is especially here that a comprehensive and balanced program of basic research can make its most effective contribution.

Basic research is also a tool of economy. Wisely used it can render completely unnecessary costly lines of applied research and development, the construction of prototypes, extensive testing, and in some cases useless manufacture. By suggesting alternatives and new lines of attack, it can shorten, sometimes by years, the time necessary to reach an important technological or medical objective. In brief, basic research is the pacemaker for applied research and development, and, moreover, it is the least expensive variety.

Yet there is in fact not enough basic scientific research being done. This has been stressed repeatedly since World War II by virtually every authority which has examined the facts. Notable among formal statements to this effect are those in Science, the Endless Frontier by Dr. Vannevar Bush; Science and Public Policy by the Chairman of the President's Scientific Research Board; Survival in the Air Age by the President's Air Policy Commission; Report of the Surgeon General's Committee on Medical School Grants and Finances; Telecommunications, a Program for Progress by the President's Communications Policy Board; by the Naval Research Advisory Committee and the Research and Development Board of the Department of Defense. Some of the estimates of the annual dollar shortage in basic research run into hundreds of millions.

Need for Government Support of Basic Research. The case for an integrated program of Federal support of basic research is based on the following considerations:

1. The major research efforts of industry have generally been in applied research directed toward immediate or short-term utility in the interest of profit to the company or utility to the public. Some highly technical industries conduct basic research and furnish special support to universities but the fields of science thus supported are usually chosen with special reference to the aims and future development of the industry.

2. Similarly, the major research efforts of governmental agencies have been in background research, applied research and development rather than basic research. Again this is because research must conform to the aims and functions of the agency in order to justify the support by the agency.

3. Under prevailing conditions and in the foreseeable future, the traditional sponsors of basic research--non-profit institutions, and particularly the colleges and universities--have only limited resources. Yet it is in these institutions where the search for new knowledge goes ahead most vigorously and imaginatively in the spirit of free inquiry, where the majority of basic research scientists are to be found, and where the entire basic training of young scientists is carried on. With additional financing from the Government they can markedly increase their output of basic research and their facilities for the training of advanced students in science.

4. A comprehensive and balanced program of basic research in the national interest can be achieved with economy only if there is central evaluation and policy development. This is necessarily a job for the Federal Government.

The Foundation's Research Program. An immediate and pressing task to which the Foundation will address itself is a careful survey which will permit an accurate evaluation of the need for support of basic research. In its approach to the problem in its initial year, the Foundation has not been able to consider development of a program adequate to the need, but has limited its plans to a program which will:

1. By establishing a limited comprehensive program of support in the basic sciences, bring the Foundation into close touch, in a working level relationship, with each of the major fields of basic scientific research;

2. In the light of existing programs in basic research place special emphasis on fields and areas where needed in the national interest.

3. Keep the organization well within its first-year capabilities for adequate assessment and administration of its program.

4. Utilize the information and experience gained in this program in the initial formulation of national policy on basic research.

While recognizing the urgent need for maximum support of basic research at the present time, the Foundation considers its recommended program the optimum approach, in view of current limitations on organization, available information and feasible activity in the first year. This is the basis for the Foundation's estimate of $8,155,000 for support of basic research in Fiscal Year 1952.

It should be noted that the program of basic research which the Foundation plans to support cannot be considered by itself a well-rounded or comprehensive basic research endeavor. Actually, it can accomplish little more than provide emergency support in the directions of greatest need.

3. Training of Scientific Manpower

Summary. The funds requested for this function are for the purpose of establishing a fellowship program which will augment scientific manpower essential for the progress of science, the national welfare and the national defense. The total estimate is as follows:

Fellowship program	$4,970,000
Operating costs of the Foundation	90,000
Total	$5,060,000

The Need for a Fellowship Program. The Foundation is authorized (Section 3(a)(4) of the National Science Foundation Act of 1950) "to award,...., scholarships and graduate fellowships in the mathematical, physical, medical, biological, engineering and other sciences."

The present need for a graduate fellowship program arises from the following facts:

(1) The continued industrial progress of the Nation is dependent on an adequate supply of trained scientists and technicians.

(2) In time of national emergency, the need for trained scientists and technicians is greater than usual. Industry must continue its normal research and development program at a reasonable level; scientists in academic institutions must to a large extent continue teaching and research; yet the Nation must enormously expand its efforts in research and development in support of the military program.

(3) Training of graduate students to the doctorate level is necessary to provide scientists who will be most productive in terms of ideas and additions to our store of basic knowledge in the sciences. The three years of post-graduate study necessary for a doctorate permit the student to attain a level of proficiency which enables him to engage in original and independent research. Generally speaking, it is here that our leaders in research are trained.

(4) A graduate fellowship program will increase the total capacity of science for all purposes including industrial progress and national defense. This increase will occur

to some extent almost at once and, over a period of years, in direct proportion to the numbers trained.

The need for trained scientists is exemplified in the following recent statement of the Scientific Manpower Advisory Committee of the National Security Resources Board, of which C. A. Thomas, President of the Monsanto Chemical Company, is Chairman:

> It is of paramount importance to the security of the United States that the nation maintain in peace and in war an adequate supply of scientifically and technically trained manpower to carry on progressive research in basic science; to design and develop devices and equipment for both military and civilian use; to sustain, broaden, and increase mass production by scientific and engineering methods; and to serve the armed forces in applied science research, technical maintenance, and the use of modern weapons.

The depletion of our national resources of highly trained manpower during the years of World War II has been pointed out in <u>Manpower for Research</u>, Volume III of <u>Science and Public Policy</u>. This indicates that the total number of persons in this class who were lost to the Nation during the war years, as a result of a lack of training due to the War, is estimated to be over 8,400. This is an important factor in the present shortage.

One of the most important considerations in the need for support of a fellowship program is the number of graduates in science adjudged competent to go on to graduate study who do not do so because of lack of finances. This is shown in a careful survey made by the National Research Council in 1948. This survey indicated that one-fourth of the college graduates receiving bachelor's degrees in that year, and judged competent by the heads of their departments to proceed to the doctorate in the natural sciences, were unable to enter graduate training because of inadequate financial support. It is estimated that, in the three-year period 1947 to 1950, over 14,000 potential Ph. D.'s in the sciences were prevented from entering graduate schools because of lack of funds.

In the immediate future, the financial factor will loom even larger as G. I. training declines. G. I. benefits were received by approximately one-half of the total number of graduate students in the sciences in the years 1948-50. This number is now decreasing and will continue to decrease rapidly. Students who have been unable for financial reasons to receive further training in the sciences represent a net loss to the Nation in trained scientific manpower.

<u>Advantages of Fellowship Program</u>. A number of advantages will accrue as a result of the fellowship program: competent students,

at present unable to pursue graduate studies for financial reasons, will be enabled to do so; post-doctoral fellowships will make it possible for mature scientists who have already received their doctorate or advanced engineering degree to spend one, and in some cases two years on specific problems in fundamental research; an increase in the number of highly trained scientists will contribute directly and in some cases immediately to the effectiveness of research activities; and the capacity of the country for all forms of research will be increased on a long range basis.

Another direct result of a fellowship program is a saving of time in training scientists. While studying on a fellowship the student can devote his entire attention to his primary work, free from commitments for teaching and other distractions. The quality of the training is also enhanced.

It is through fellowship opportunities that some of the most important pioneering work in science will be done. Especially in the case of the post-doctoral fellowships, which will be relatively few in number, will there be an opportunity to develop future leaders in research and education. Proof may be found in the experience of the National Research Council in administering its own limited program of post-doctoral fellowships over the last thirty years. From the scientists who held National Research Council fellowships have come many of today's eminent scientists, educators, and leaders in industrial and government research. During the war former National Research Council fellows played leading roles in the development of the atomic bomb, radar and radar counter-measures, and the proximity fuse.

The fellowship program represents a relatively small investment with the near certainty of great gains in the future.

Distribution of Fellowships. In arriving at the optimum number and distribution of the proposed science fellowships, account has been taken of existing sources of support as well as the local opportunities for such aid in the hands of private institutions (the latter being available mainly during the last years of graduate study). The table below sets forth the estimated number of fellowships to be provided under funds made available by the National Science Foundation program, principally for use in the academic year 1952-53:

Graduate Level	Number
First year	1,400
Second year	400
Third year	200
Post-doctoral	100
Total	2,100

Of the total number of graduate students in the fields of science and engineering in 1950, the proposed number of graduate fellowships in this estimate amounts to 3.6 percent. The number of fellowships recommended for the first year of graduate study comprises 4.5 percent of the total number of first-year graduate students, and the number of fellowships recommended for the second year comprises 2.2 percent of the total number of second-year graduate students. The fellowship program will thus provide assistance to a small but highly select fraction of the total graduate student body.

The largest number of fellowships is provided for the first year of graduate study. This is the critical time in the selection of graduate fellows since a delay means a loss in continuity of training and increases the possibility that the students will be permanently lost as scientists. Other fellowship programs, for example, the Guggenheim and NRC fellowships, aim at graduate students in later years, the third or post-doctoral years.

Selection of Fellows. Fellows under the proposed program will be selected solely upon the basis of ability, as required by the National Science Foundation Act, with appropriate consideration being given to wide distribution throughout the Nation in the case of applicants deemed to be of substantially equal ability. Fellowships will be granted on a one-year basis with the possibility of a renewal.

The National Research Council, because of its experience in fellowship program administration, is the logical agency to administer the Foundation's fellowship program in the opening year. Accordingly, the Foundation plans to arrange with the NRC for the initial selection of candidates for these fellowships and for a substantial amount of the administrative work involved in carrying it out. Final appointments, as required by law, will be made by the Foundation.

Estimate of Cost. In developing estimates, the Foundation must necessarily rely in the beginning for information from other fellowship programs. Based on the experience of the National Research Council, the Atomic Energy Commission, and the Public Health Service, an average cost of slightly less than $2300 per fellowship is a reasonable estimate. This would include on the average a stipend of about $1600, tuition of $500, an allowance for dependents of $100 and an allowance for procurement of technical equipment and materials of $100. In addition, experience shows that a competent job of testing and selection for a program of this size should run somewhat less than 10 percent of the total amount distributed to recipients. A tentative distribution of the cost required for the program in 1952 is as follows:

Level	Number	Average Cost	Total Cost
First year	1400	$2,000	$2,800,000
Second year	400	2,300	920,000
Third year	200	2,500	500,000
Post-doctoral	100	3,500	350,000
	2100	$2,176	$4,570,000
Cost of testing and selection......................			400,000
Total cost of program......................			$4,970,000