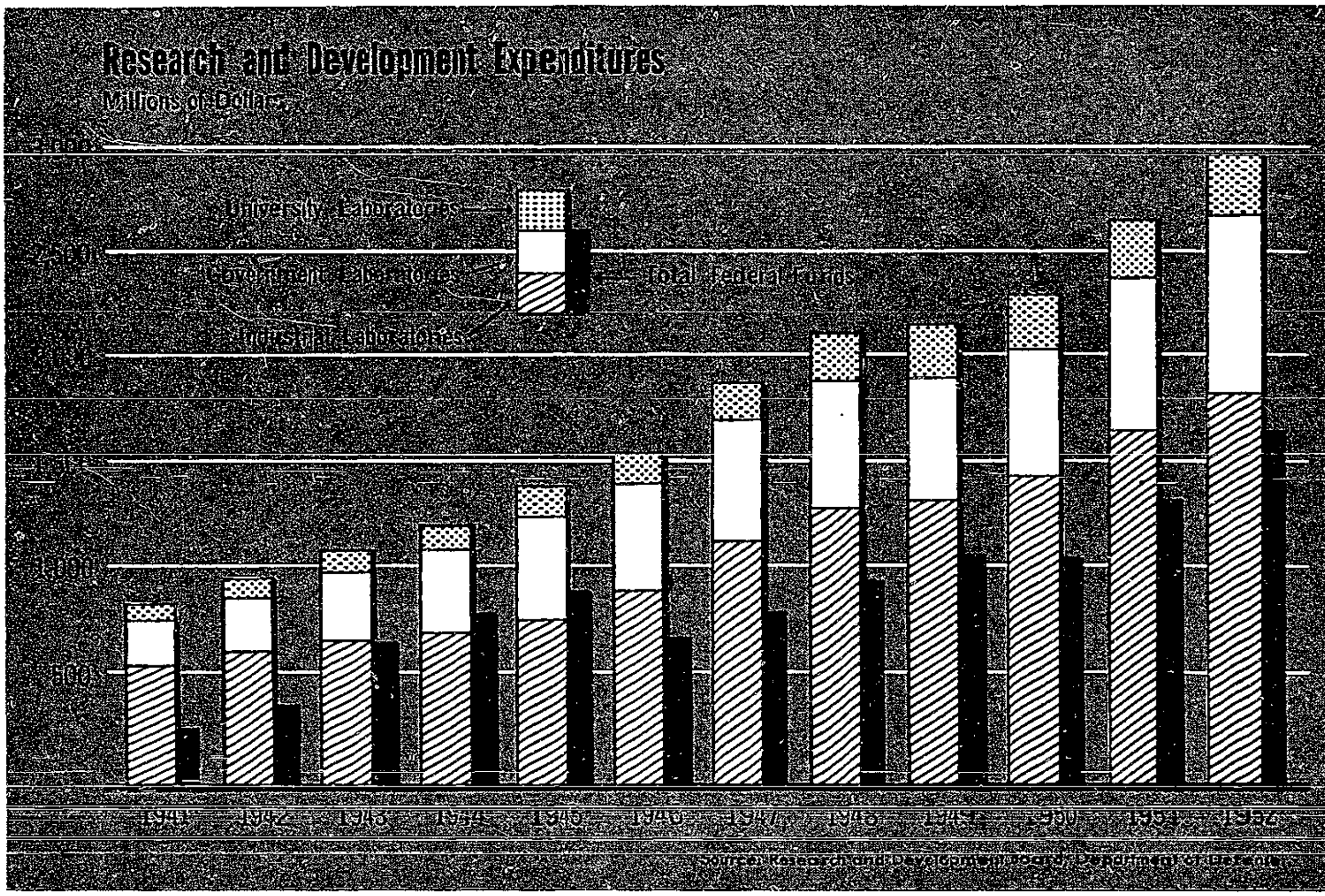



A C&EN STAFF REPORT

# Developing a National Science

WITHIN a few days now, officials and friends of the National Science Foundation will go before House and Senate appropriations committees of the 83rd Congress. Then congressmen will have an opportunity to give a sharp scrutiny to the foundation's budget request for $15 million for fiscal 1954. A quite natural question is going to be, "What have you accomplished since the President signed the National Science Foundation Act in May 1950? Specifically, what is the country getting for the nearly $8.5 million we have given you since that time?"

Just because there is a law, scientists cannot be complacent about NSF's future, if Congress' past performances are typical. Witness what has happened: In August 1951 the House cut the request for fiscal 1952 exactly 98%—from $14 million to $300,000—and much effort was necessary to get the budget restored to a most inadequate $3.5 million. In fiscal 1953, the House again wielded a heavy knife—the $15 million request was cut to $3.5 million. This was upped by the Senate and finally set at $4.75 million by a Senate-House conference.

That NSF should come so close to receiving these death blows seems little short of fantastic. Legislation creating the foundation was considered by one or both houses during five sessions of Congress. Over 1200 pages of testimony by 150 of the Nation's leading authorities in science, education, and medicine were taken. The Hoover Commission supported NSF legislation. The President's Scientific Research Board recommended in "Science and Public Policy" (Steelman Report, 1947) that the Government should be spending $250 million annually by 1957 to support basic research in universities and other nonprofit organizations. It also said that a National Science Foundation should be established to make grants for basic research.

The atmosphere in Congress is not entirely unfriendly; on the contrary, NSF will have friends there—Senators Alexander Smith, Saltonstall, Magnuson, Kilgore; Representatives Priest, Heselton, Wolverton, to name but a few. But many others still have to be sold on the importance of science.

What can NSF sell? National security,

for one thing. "Look, gentlemen, at what happened to Germany," it can say. In 1940 the Germans all but stopped basic research and concentrated on development and production. Within three short years, they were trying frantically to restore a strong program, but it was just three years too late. They missed out on microwave radar, the proximity fuse, and the atomic bomb, to mention only a few "achievements."

NSF can also show how the time lag between the discovery of basic principles and their application has all but disappeared. "Literature cited" sections in scientific articles today refer largely to publications not over four to six years old. If we want to be militarily secure, NSF can say, we cannot stand still or even continue to move at the same pace: There must be more basic research.

**Breakdown of NSF Main Expenditures**

| | Actual 1951 | Actual 1952 | Estimate 1953 | Asking 1954 |
|---|---|---|---|---|
| Development of U. S. Policy | $ 75,463 | $ 559,110 | $1,175,000 | $ 1,584,000 |
| Research Support | 53,472 | 1,243,651 | 2,120,000 | 8,878,000 |
| Scientific Manpower and Education | 21,993 | 1,663,239 | 1,489,000 | 4,574,000 |
| Total | $150,928 | $3,466,000 | $4,784,000 | $15,000,000 |

The Research and Development Board estimates that $3.5 billion was spent last year for all types of research. Of this total, about 60% was spent in industrial laboratories, 30% in federal facilities, and 10% in universities and other nonprofit organizations (see chart, page 228). Now universities and nonprofit groups account for the major share of research (about 85%), but not all of their research is basic. The ratio of applied research and development to basic research being done by these groups is about three to one, and there is every indication that this ratio will increase.

These figures are shaky estimates, to be sure, but they indicate that the U. S. is spending about $150 million on basic problems. Just what the basic research deficit is, no one can say (after all, what is "enough"?), but there have been at least two firm estimates as to what the Government should be doing. The Steelman Report, mentioned previously, suggested in 1947 that Government support of basic research in universities and nonprofit organizations should be about $250 million by 1957; the Paley Report said last year that NSF should get the full $15 million allowed by its enabling act each year, in addition to removing the present appropriation ceiling placed on NSF's budget. Neither the U. S. as a whole nor NSF is close to these suggested figures. Whatever the "correct" amounts may be, most scientists and Government officials agree that the present level is far from adequate.

Supporting research, important though it may be, is not an end in itself for the foundation. Nor is telling Congress how important basic research is and what effect it can have on the nation's security its most important goal. There are many facets to the nation's scientific effort and the problems facing it. Money, facilities, coordinating research, sponsoring research improving methods for exchanging information are a few of them. Another (and critical one) is the problem of men—men in research, men teaching, men in training for the future.

NSF's main job is to take all these problems, determine how they bear on one another, and evolve an integrated policy at the national level to deal with them. It is this integration that it plans to stress to Congress this year.

### Government Interest in Science

"New frontiers of the mind are before us, and if they are pioneered with the same vision, boldness, and drive with which we have waged this war, we can create a fuller and more fruitful employment and a fuller and more fruitful life." Thus Franklin Roosevelt wrote to Vannevar Bush in November 1944, asking that he study the Nation's science needs and recommend what should be done. Bush answered in "Science, the Endless Frontier" that one of the things the country should do was establish a Government agency which would develop a national policy for scientific research and education and support basic research in nonprofit organizations. This Government agency, Bush felt, should also develop scientific talent in American youth with scholarships and fellowships, and it should support long-range military research.

The Bush report is not the only antecedent of NSF legislation. A subcommittee on war mobilization of the Committee on Military Affairs held hearings on the significance of science and technological mobilization in the war effort, and in 1943 recommended that an Office of Scientific and Technical Mobilization be established. This office was to concern itself chiefly with technological mobilization for war. A bill for this purpose was introduced, but it died in committee. Subsequent drafts of the bill changed the emphasis to an agency that would sponsor and coordinate peacetime, as well as wartime, research.

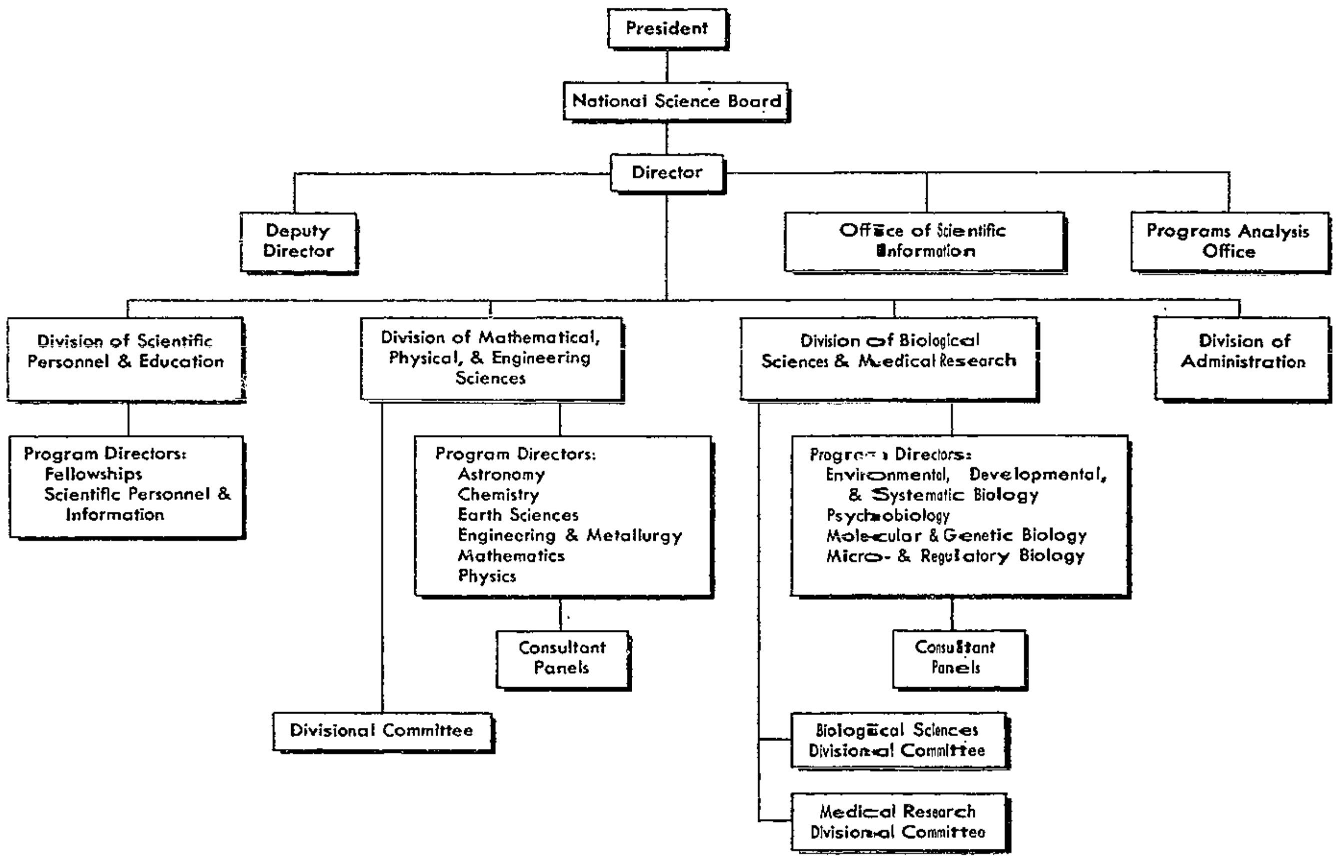
The idea for a National Science Foundation was in a subcommittee report made shortly after the Bush report appeared in

# Foundation

## Specific functions of NSF:

- **To develop a national policy for the promotion of basic research and education in the sciences.**
- **To support basic scientific research and to appraise the impact of research upon industrial development and the general welfare.**
- **At the request of the Secretary of Defense, to support specific defense research activities.**
- **To award scholarships and graduate fellowships in the sciences.**
- **To foster the exchange of scientific information.**
- **To maintain a register of scientific and technical personnel and to serve as a central clearing house for such personnel.**
- **To evaluate scientific research undertaken by Federal agencies and to correlate the foundation's research programs with other such programs.**
- **To cooperate in international scientific research activities.**

## Organization Chart—National Science Foundation




1945. No action was taken on any of these proposals, however, until 1946 when a National Science Foundation bill was finally reported out of committee.

In reality, NSF is only one of the many plans by which the Government has evidenced interest in what might be termed broad-spectrum science. The first concrete action was taken 107 years ago when Congress established the Smithsonian Institution. Next came the National Academy of Sciences, incorporated by Congress in 1863. This body investigates and reports on matters pertaining to "science or art" when requested to do so by any Government agency. A more recent addition is the National Research Council, which was made a permanent part of the academy in 1918 as the academy's agent in dealing with the Government.

The war and postwar years have been ones of increased Government interest in science. Congress, the executive branch, and private groups made recommendations. Special committees were established. One was the National Defense Research Committee, organized in June 1940, and later named Office of Scientific Research and Development.

It was not long before it became evident that there would be a postwar need for a permanent organization to direct the country's peacetime and wartime science needs. The secretaries of the armed forces, concerned over what would happen when OSRD would end, named a committee on postwar research to study needs of the services. In November 1944, this committee, headed by General Electric's Charles E. Wilson, recommended that a Research Board for National Security be established within the National Academy of Sciences. This was never done, but support for a permanent federal agency responsible for over-all science policy continued along other lines.

The Office of Naval Research was an important addition to the Government's research program in 1946. Its purpose was to coordinate the research activities of the Navy, but its interests were rather broad during its first few years. Now that a National Science Foundation is in existence, ONR has narrowed its field of interest to matters of more direct naval interest.

ONR is regarded by many as having sustained general basic research during the immediate postwar years when no other federal agency was doing so. Not to be forgotten, however, are the Atomic Energy Commission, an outgrowth of the Manhattan Engineering District in 1946, and the National Institutes of Health (1930).

Finally, on May 10, 1950, the President signed the National Science Foundation Act, the result of nearly 10 years of discussion. Five sessions of Congress had considered legislation. A bill had actually passed both houses in 1947 only to be vetoed by the President as unworkable.

NSF is unique among Government agencies. It is the only one concerned with developing an over-all national science policy, and it is the sole Government agency that supports basic science with no thought of immediate "practical" gain.

In addition to its over-all objective of developing and coordinating national science policy, Congress has given NSF seven specific jobs, mentioned in the list on page 229. Those charged with organizing NSF felt that it should operate with a minimum of administrative work. Instead of spelling out in great detail what would be done for all conceivable situations, NSF relies on the knowledge and opinion of a great array of consultants. These men, outstanding leaders in their areas of specialization, can bring many years of experience to bear in making decisions, thus deciding individual issues on their merits rather than by arbitrary rules.

NSF's permanent staff is small, numbering about 100 fulltime workers. The major policy body is the 24-man National Science Board. These men, appointed by the President and confirmed by the Senate, serve for six years. The present board was appointed in November 1950 and includes men prominent in basic science, medical

A. T. Waterman, Director — C. E. Sunderland, Deputy Director — Paul E. Klopsteg, Associate Director — Raymond J. Seeger, Acting Assistant Director for Mathematical, Physical, and Engineering Sciences — Walter Kirner, Acting Program Director for Chemistry — Ralph A. Morgen, Program Director for Engineering

science, engineering, agriculture, education, and public affairs.

The director of NFS is also appointed by the President for a six-year term, and he is the chief executive officer co-equal with the board. The first director is Alan T. Waterman, who was appointed in April 1951.

### Organization Structure

How NSF is organized is shown on page 230. It is divided into four divisions and two offices which report to the director. Three of the divisions are "operating" —the divisions of mathematical, physical, and engineering sciences; of biological sciences and medical research; and of scientific personnel and education. The fourth division is the administrative division.

The first two divisions administer research grants, and the third administers the fellowship program, handles surveys on manpower resources, and maintains the register of scientific personnel. The programs analysis office acts as a center for studies which will assist in developing national science policy. The Office of Scientific Information compiles and exchanges information about scientific research and development and acts as the public information office for NSF.

Acting in advisory capacity to the two research support divisions are three divisional committees. (The division of biological sciences and medical research was originally two divisions—biological sciences and medical research. They have since been combined into one division for administering grants in the two areas, but the two divisional committees have been retained.) These committees, consisting of seven to 10 men each, meet several times a year to discuss policy problems in their areas and advise their division's director on such matters.

Both "grant" divisions are further divided into particular scientific areas, each headed by a program director. These men have panels of consultants to assist them in evaluating proposals and in keeping abreast of the current status of work and problems in their particular areas.

In deciding how to start developing a national science policy, the foundation concluded that one of the first needs would be to develop programs for research support and fellowships. The basic idea here is to get more men, more good men, into the professions. Men are needed in industry, in government, and above all in universities. The grant and fellowship programs approach the problem from both directions and complement each other. A strong university research program throughout the country should attract additional students; they, in turn, can be given the opportunity to continue their education and will be stimulated to enter research, teaching, or industry at a high level. This interaction, NSF believes, will snowball to give the nation a strong science position. In terms of dollars, NSF puts approximately equal emphasis on both programs.

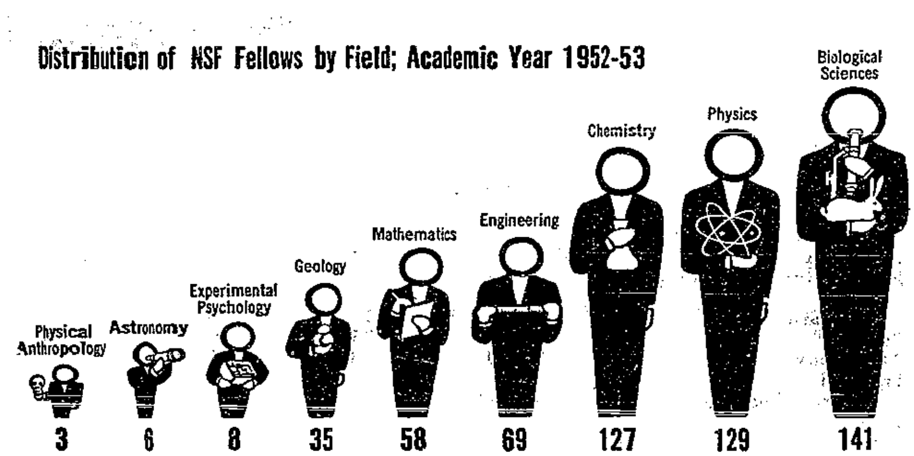
Part of the manpower problem is a problem of concentration. Illustrative of this concentration is a Research and Development Board finding: 11 universities got half of the government research support during fiscal years 1948 to 1950; 65 universities accounted for 90%. A similar concentration is probably true of industrial support programs.

One of the dangers of concentration is that the actual research may suffer. The over-all plans at giant research centers would be beautiful; there wouldn't be much chance for mistakes or duplication, but there are those who feel there would be little chance of making discoveries.

Of more fundamental importance, however, is the changing character of these institutions themselves. Are they in business for education or for administering research? Is research demanding so much of the attention of the professors that they have little time left over for training men for the future?

There is no question but that conducting research stimulates a man's teaching. How much research universities can afford to do without destroying their primary function of education, however, is something that only they can decide, in NSF's view. Part of the foundation's job is to seek out those men who could contribute more and support them. The research support program to date has shown that there must be large untapped resources in the universities. The number of proposals of high merit come from a relatively small number of centers, especially in the engineering sciences. In an effort to tap other sources, NSF has made almost 75% of its grants to institutions that have participated least in previous Federal research activities.

A different concentration is being noted among fellowship recipients. Naturally, fellows are choosing those schools with the strongest programs. One group of 71 in the physical and engineering sciences, for instance comes from 21 states. They received their training in over 50 institutions. However, 43 of them have chosen six schools and 12 have chosen four other schools, so that 77.4% of them have selected 10 schools. Having graduate students in a larger number of schools would give the country a stronger science potential, and NSF's policy of distribut-



ing grants as widely as possible is directed toward that end.

Finding men in the universities to do research is where members of the consultant panels make an important contribution. Being leaders in their fields, they are thoroughly familiar with who is doing what and what his capabilities are. These men, with an intimate acquaintance with their fields, enable NSF to operate with a minimum of red tape and administrative detail.

### Grant Program

The law gives NSF a good deal of discretion in selecting the mechanism it is to use in its support programs. Grants, loans, and contracts are the general types of support mechanisms used by others. This variation is partly due to the laws under which different agencies operate and partly to agency philosophy.

Although the grant is a formal agreement, the foundation has shied away from any mechanism that requires an agreement spelled out in bookkeeping minutae down to the last eraser. In the broad fundamental areas in which NSF operates, it is virtually impossible to write specifications: Fundamental research does not lend itself to that type of treatment.

Grants are used almost entirely by private endowing groups, and they require a minimum of administrative work to operate satisfactorily. Therefore, NSF is using grants extensively for research support.

The consultants also fill a vital need in administering the grant program. In the absence of a highly specific agreement specifying performance and objectives, a somewhat subjective evaluation must be made of what the prospective grantee can be expected to achieve. Such an evaluation the consultants can make. NSF recognizes, of course, that these evaluations may not be correct every time, but it believes they are much superior to arbitrary rules and specific agreements. The country is adequately protected against fraud, of course, should a grantee accept money for a project and then do little or nothing.

What happens to a request when it is received is shown in the flow sheet on page 233. One very important decision that must be made is whether the proposal should be supported by NSF. NSF says that it rarely has to face the problem of basic vs. applied research, certainly not to the extent of spelling out guiding principles for what is basic and what is applied. In the first place, it says, most of the proposals it receives are of a broad general nature anyway. Also, the professional caliber of its consultants is such that it feels they can spot proposals having broad significance without requiring specific rules. And finally, those proposals of less importance will drop out because only the best will be supported with the limited funds available.

The worker agrees to carry out the work in conformity with a statement of aim and scope of the project. What the country gets for its money will be largely due to his ability. Just how extensive the auditing of each individual grant is, the foundation cannot decide alone, since certain requirements of the General Accounting Office must be met. NSF hopes to keep auditing to a minimum, however. The average grant is about $6000, and NSF's limited budget will not go very far if several hundred dollars are used to audit each grant extensively.

The foundation likes to know what its grantees are doing, and to this end each recipient makes informal scientific progress reports at least once a year. Publication of papers is encouraged, and they may take the place of reports.

In the event patentable information is obtained, the grantee may apply for a patent at his discretion. The sole provision is that NSF be notified if an application is made and that the Government have a royalty-free license if one is issued.

As of December 31, NSF had made 231 grants totaling $2,481,225. Table I shows how this money has been divided. To date, the research budget has been divided almost equally between the two divisions administering grants. There has been more basic research in chemistry than in any of the other physical sciences, probably because more good chemistry proposals by chemists have been received than from the other areas. Following closely in number is physics, with engineering, mathematics, earth sciences, and astronomy following in that order.

**Table I. Distribution of Grants as of Dec. 31, 1952**

| | Grants | Amount |
|---|---|---|
| Biological and Medical Sciences | 105 | $1,210,215 |
| Development Biology | 12 | 102,675 |
| Environmental Biology | 5 | 28,060 |
| Genetic Biology | 10 | 164,900 |
| Microbiology | 18 | 173,600 |
| Molecular Biology | 16 | 225,300 |
| Psychobiology | 3 | 31,200 |
| Regulatory Biology | 25 | 311,700 |
| Systematic Biology | 17 | 172,780 |
| Mathematical, Physical, and Engineering Sciences | 106 | $1,017,950 |
| Astronomy | 4 | 60,000 |
| Chemistry | 34 | 324,200 |
| Earth Sciences | 6 | 51,450 |
| Engineering Sciences | 18 | 157,200 |
| Mathematics | 15 | 79,900 |
| Physics | 29 | 345,200 |
| Other* | 20 | $ 253,060 |
| Grand Total | 231 | $2,481,225 |

* Research Education, Scientific Information, and Studies in Science.

**Table II. Distribution of Accepted Fellowships by Year of Study and Field, Academic Year 1952–53**

| | 1st Year | 2nd Year | 3rd Year | Postgraduate | Total |
|---|---|---|---|---|---|
| Biological Sciences | 26 | 40 | 66 | 9 | 141 |
| Chemistry | 42 | 37 | 44 | 4 | 127 |
| Engineering | 30 | 22 | 16 | 1 | 69 |
| Geology | 6 | 10 | 16 | 3 | 35 |
| Mathematics | 13 | 20 | 17 | 8 | 58 |
| Physics | 36 | 33 | 51 | 9 | 129 |
| Astronomy | 1 | 1 | 3 | 1 | 6 |
| Physical Anthropology | 1 | 0 | 2 | 0 | 3 |
| Experimental Psychology | 1 | 1 | 3 | 3 | 8 |
| Totals | 156 | 164 | 218 | 38 | 576 |

### Fellowship Program

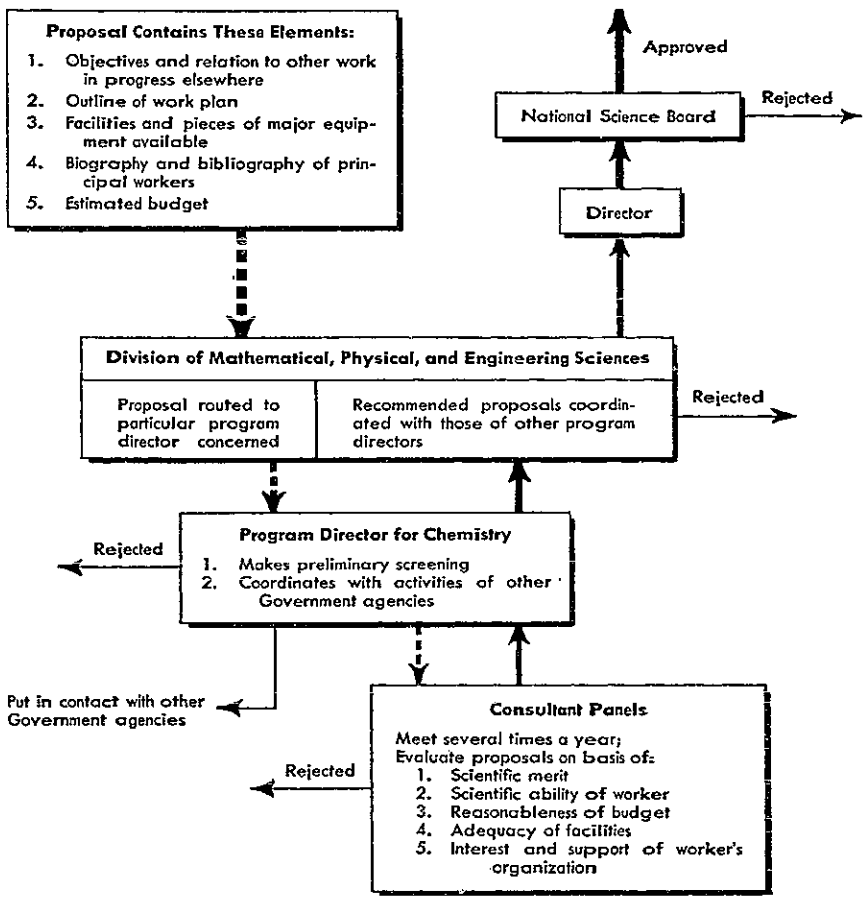
Closely allied with the grant program is the one on fellowships. This program is administered by the third NSF operating division, the division of scientific personnel and education. NSF's actions to date in this area have been dictated to a large extent by the exigencies caused by the nation's manpower problems.

Academic 1952–53 was the first year for which NSF had funds for supporting students. NSF can award both scholarships and fellowships, but when the program was being organized in the late fall of 1951, NSF officials decided that emphasis should be placed on graduate fellowships. This would give the most immediate relief to the long-range manpower program.

Secondary emphasis was placed on support of postdoctoral work, and undergraduate scholarships were not to be awarded at all. Whether there will be a change in this policy in the future, NSF is not saying yet. Changes will depend on the money available and the needs NSF believes should be met as it gets a clearer picture of just where the nation should and can go science-wise.

All graduate students in mathematics, physical and biological sciences, and en-

## How Research Proposals Are Evaluated and Selected




gineering are eligible (in the field of medicine, no awards are being made for work leading to an M.D., but awards are being made to those who wish to do medical research). The National Research Council, which has had extensive experience in administering fellowship programs, screens and evaluates applications. NSF then makes the final selection.

Awards are made on much the same basis as are research grants, with greatest weight being given to ability of the applicant. The foundation has tried to set ability standards at the same level for each of the fields so that all will be judged on approximately the same basis. This assures that the top students will receive fellowships. However, at the cut-off point on the ability gradient, decisions cannot be so clearcut because there will probably be several students of about equal ability. To decide among these, NSF calls on geography to help: It selects those from areas of the country which have contributed the fewest graduate students. The foundation estimates that perhaps 10% of those selected are effected by this policy.

The first class of fellows is now pursuing graduate and postgraduate studies in 65 institutions in this country and in 16 other countries. About 66% of those in this country are in private institutions and the balance in public institutions. They were selected from about 3000 applicants from every state in the Nation as well as from Alaska, Hawaii, Puerto Rico, and from American students in Canada, England, and France. Because of the budget limitations, it was possible to award only 624 fellowships, 576 of which were accepted. Percentages of fellows in the various fields are shown in the chart on page 231 and distribution by field and year of study is shown in Table II.

Plans for 1953–54 are essentially the same as those for the first year. Cut-off date for receipt of applications was December 31. NSF expects to be able to support about 500 fellows this year. The National Research Council will again make the preliminary screening, the NSF the final selection.

Of fundamental importance is the foundation's work in establishing and coordinating science policy. What is needed for these policy decisions is more definitive information on the entire science activity in the U. S.—federal, state, industry, and nonprofit organization. How science has contributed in the past, who paid for that contribution, how science can contribute in the future, and what support should be given to it as a whole and to individual parts, are questions that need to be answered. As the information becomes available, NSF can then paint the picture: "Here is where we are; here is where we should go."

A number of programs have already been started to gather specific data and opinion. Last spring a Programs Analysis Office was set up to act as a center for studies which will assist in formulating policy. This office also gathers statistical data on the federal research program, a function of the Budget Bureau in the past.

Studies are now under way in physiology, psychology, and applied mathematics. Content, method, manpower, and facilities for research and education are being analyzed by leading scientists in each field.

In addition to the statistical and survey studies, several conferences have been held in the past few months. Among them were conferences on low temperature physics, abundance of the elements, photosynthesis, and high energy particles. Others will be scheduled as the need arises. These conferences bring together outstanding experimenters and theoreticians to exchange information and to review current research in their fields. They provide the foundation with background necessary for planning its own research support programs, and they also stimulate new research in the particular areas.

Compilation of a register of scientific personnel is under way, and information on publication backlogs and financial problems of some 200 journals that publish results of original research has been gathered and is now being analyzed.

NSF has not "cooperated in international scientific research activities" to the extent of sponsoring research, since it is not in a position to do so yet. However, it has established liaison with the State Department's Office of the Science Advisor and with the National Research Council, both of which have international responsibilities in science. Liaison has also been established with other similar foreign organizations. To implement international exchange of information, travel grants were given to four mathematicians to attend the first general assembly of the International Mathematical Union in Rome last March. Nineteen biochemists received similar grants for travel to the second International Congress of Biochemistry in Paris last July.

Through these studies, conferences, and surveys, the foundation hopes to obtain the necessary data for the development of sound national policy. The results will be valuable not only to NSF but to all federal agencies administering research support programs.

And that is where NSF is today. What benefits it can bring to the country will depend in large measure on the money it receives, and what Congress will do is none too certain. NSF officials are hopeful, not resigned. Cooperation on the part of the nation's scientists the past three years has been heartening, they report, and they expect these same men to get in and help if Congressional action on the budget proves to be too severe.