SCIENTIFIC MANPOWER AND GRADUATE FELLOWSHIP PROGRAM

In April 1952, the Foundation awarded 624 graduate fellowships in the sciences for the academic year 1952–53. Of the total 569 awards were made to predoctoral graduate students, while 55 were made to post-doctoral applicants. A complete list of the awards is given in Appendix IV, p. 56. The fellows were selected from about 3,000 applicants from all parts of the United States, its territories and possessions, and from American citizens abroad. Fellows were selected solely on the basis of ability, with awards made in cases of substantially equal ability so as to result in a wide geographical distribution.

Of the predoctoral fellowships 169 (27 percent) were awarded to graduating college seniors entering their first year of graduate study. A total of 170 awards were made to second year graduate students, and the remaining 230 to advanced predoctoral students. This pattern of distribution by year of study is in contrast with that of previous Federal fellowship programs in its emphasis upon first year awards. By encouraging graduating seniors to begin and continue advanced studies the Foundation hopes to increase the supply of trained scientists and engineers in the shortest possible time during a period when there is great need for more individuals with advanced training.

The largest group of fellowships, 158, was awarded to graduates in the biological sciences, which compares with 140 in chemistry, 137 in physics, 75 in engineering, 62 in mathematics, 36 in earth sciences, 7 in agriculture, 6 in astronomy, and 3 in anthropology.

All regions of the United States were represented among the selected fellows. Both applications and awards were roughly proportional to the total population, and the population attending colleges in the various regions. Tables showing breakdown of awards by subject and year of study and geographical origin are given in Appendix IV, p. 55. Analysis of the institutions at which fellows received their undergraduate training confirms previous studies of the importance of small, liberal arts colleges as a source of scientific talent.

As was anticipated the successful fellows, free to attend graduate institutions of their own choosing, showed a tendency to seek training at a highly selected group of institutions. (See Appendix IV, p. 67). The extent to which this tendency is undesirable requires further study. The Foundation and its advisory groups are giving serious consideration to the question. One obvious corrective measure is to strengthen teaching and research faculties of a greater number of graduate schools. The Foundation is helping to do this through its research support program.

SELECTION PROCESS

Predoctoral applicants were screened on the basis of:

1. Test scores on scientific aptitude and achievement examinations.
2. Previous academic record.
3. Recommendations from faculty advisors and others in a position to know the candidate and his scientific abilities.

This part of the selection procedure was administered for the Foundation by the National Research Council of the National Academy of Sciences. The predoctoral examination for scientific aptitude and achievement was conducted by the Educational Testing Service, Princeton, New Jersey. Panels of outstanding scientists in each scientific field were established by the Council to review and rate the applications. During the preliminary screening the total list of applicants was reduced by about one-half. A final screening by a second group of panels established a list of superior candidates which was submitted to the Foundation for the final selection of fellows.

Postdoctoral fellows were screened in a similar manner except that no examination was required. During the review it was clear that there were two broad classes of postdoctoral applicants, namely: recent recipients of doctorate degrees who desired to proceed with an additional year of specialized training, and senior scientists who received their doctorates some years ago and desired and needed additional training at this time. In the final selection 5 awards were made to senior scientists, while 50 awards were made to younger scientists.

TERMS AND STIPENDS

National Science Foundation fellows are expected to devote full time to advanced scientific study for the full tenure of the fellowship. The results of research carried out by a fellow during his training may be made available to the public without restriction, except as is required in the interests of national security, in accepting a Foundation graduate fellowship, the recipient is not committed to accepting future Federal employment nor is the Federal government committed to offering employment to any fellow.

Stipends for the National Science Foundation fellowships vary with the academic status of the fellows. First year fellows receive a basic stipend of $1,400; second year, $1,600; advanced predoctoral, $1,700; and postdoctoral, $3,000 per year. Second year, advanced predoctoral and postdoctoral fellows receive an additional allowance for wives and children. Normal tuition and laboratory fees are paid by the Foundation, and limited travel allowances are provided. Slight adjustments in the schedule of stipends will be made for the academic year 1953–54 in accordance with interagency agreement on standard stipends. Under the new schedule the basic stipend for terminal year fellows will be $1,800 per year and the postdoctoral stipend will be increased to $3,400. Stipends for first year fellows will continue at $1,400 per year with $1,600 for intermediate years.

RELATION TO NEED

While the graduate fellowship program has an immediate effect upon the shortage in scientists, it by no means can solve the whole problem. The Foundation clearly recognizes that the scientific and technical manpower shortage stems from deep roots in our educational, social and economic structure and that its eventual correction will require long-range attack on these underlying problem areas.

Accurate estimates of the extent of the current shortage of scientific manpower are difficult to obtain. All of the evidence indicates, however, that shortages of varying severity exist in most of the scientific disciplines, and in engineering shortages appear to be especially critical. Headlines such as these from the *New York Times* are typical:

Government Seeks Scientists

Engineers Scarce in Plane Industry

Skilled Scientific Manpower
One of Nation's Great Needs

Lack of Scientists in Defense Feared

Such headlines are eloquently supported by columns of classified advertising devoted to recruitment of engineers and physicists. Appeals for persons of these qualifications are frequently broadcast, and the United States Employment Service reports an increased number of listings in these categories.

One informed estimate places the annual need for engineering graduates at 30,000 and another fixes the present shortage at about 96,000 engineers. In the chemical field, J. H. Lux and L. S. Moody predict an average deficit in the number of chemists increasing from 3,000 in 1951 to 8,000 by 1953. The average deficit in the number of chemical engineers is expected to increase from 9,000 in 1951 to 41,000 by 1955. The placement bureau of the American Institute of Physics reports the number of listed jobs had increased 420 percent in 1951 over 1950, while the number of registrants decreased 16 percent.

The United States is currently falling behind on the production of new scientists at the rate of 10 percent or more a year. M. H. Trytten, director, Office of Scientific Personnel, National Research Council, reports that at one meeting in 1951, representatives of 16 major industrial employers of scientific personnel announced that "after scouting the Nation's graduating classes they were able to obtain on the average only 36 percent of the new employees needed." The Department of Defense, its laboratories, and contractors experience considerable difficulty in staffing projects under way. The Atomic Energy Commission reports similar problems. Planning for future expansion is seriously modified in these agencies by the knowledge that scientific and technical manpower is so limited.

The number of engineers who have graduated from our schools has declined in recent years and is expected to reach a low of about 15,000 graduates by 1955. On the basis of present and foreseeable college enrollments it seems unlikely that the desired level of 30,000 engineering graduates a year can be reached before 1965.

It is of interest to note that the Soviet Union plans for a constantly increasing number of engineering graduates. Goals for 1955 call for nearly 50,000 engineering graduates, which represents a steady rise from a low point of 9,000 graduates in 1943. The chart on page 26 compares the trends in production of engineering graduates in the United States and the Soviet Union for the 16-year period, 1940–55.

Some 34,000 Ph. D. and D. Sc. scientists plus about 6,000 additional scientists having equivalent training represent a crucial element in the scientific manpower situation. These 40,000 men and women make up

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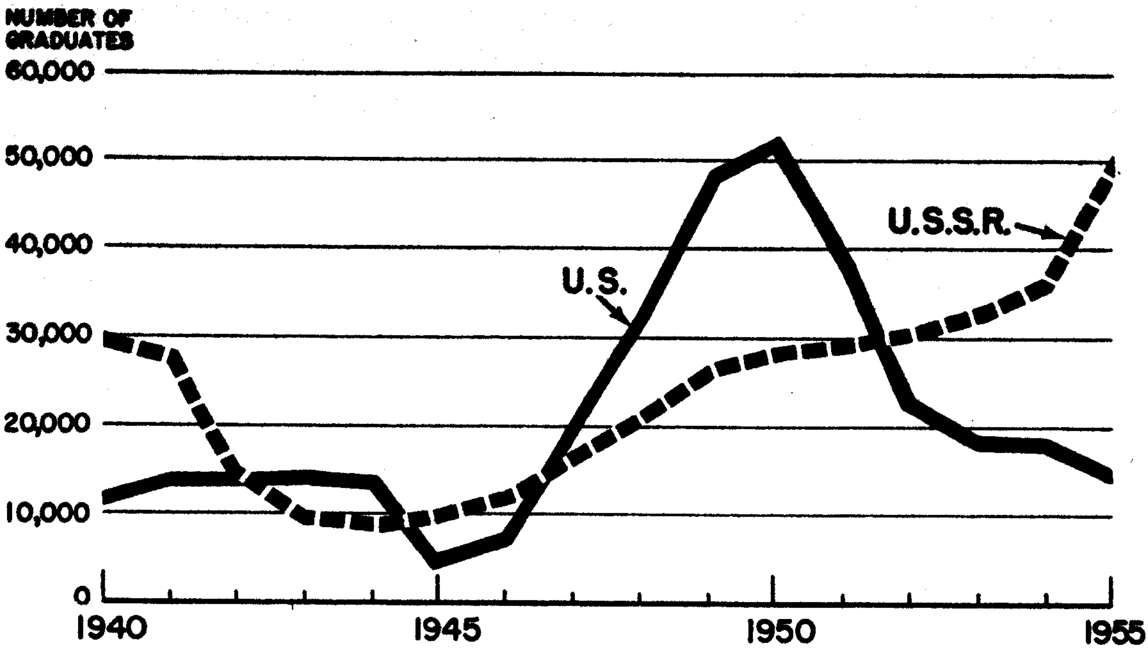

ENGINEERING GRADUATES IN THE UNITED STATES AND THE SOVIET UNION, 1940–55

Source: U. S. figures from Hollister, S. C., from U. S. Bureau of Labor Statistics, U. S. Office of Education, American Society for Engineering Education, and Engineering Manpower Commission of Engineers Joint Council (August 21, 1951). U. S. S. R. figures from Bartosek, Milan, *Vysoke Skolstvi S. S. S. R.*, Prague, 1947.

the research core of the Nation. These are the ones who, as a result of their training, carry on advanced research for their country. Upon this group we also depend for most of the advanced teaching in science.

The rate at which new Ph. D.'s and D. Sc.'s are being produced is therefore a matter of considerable importance. At present the rate of production is about 3,600 new doctorates in the sciences every year, or something less than 10 percent of the total. This rate is too low to keep up with the normal growth of technology, the expanded current needs. In addition there are signs that the present rate is near a peak unless extraordinary action is taken. According to Dean George R. Harrison of the Massachusetts Institute of Technology we may expect not only the number of scientists to decrease but the number of research scientists to decline even more radically. Dean Harrison points to the declining enrollment in undergraduate science courses and the effect of the low birth rate during the depression years.

The current deficit in scientists may be traced in part to the effect of World War II upon the number of science students. The American Council on Education in 1951 stated "that the loss occasioned by World War II in the number of doctorates produced in science was in the neighborhood of 10,000, possibly much higher."

It is worth noting that the deficits produced by World War II have not been offset by the veterans training program under the G. I. Bill of Rights. The postwar upsurge in the production of baccalaureate degrees in science and engineering reached a peak of 125,600 in 1950. The graduating classes of 1951 and 1952 decreased markedly from this record number. The downward trend will continue at least into 1954. The number of students expected to receive baccalaureate degrees in June 1954 will be much lower than the number awarded in 1950, yet the number of Ph. D. awards to be made in 1954, representing members of the 1950 college graduating classes, will clearly be too few to make any appreciable impact on the accumulated shortage of scientists. Thus, we can expect the problem to grow more critical.

LONG-TERM NATURE OF THE PROBLEM

During the first half of the twentieth century, the various fields of science underwent periods of expansion at different times in response to specific economic or military stimuli. For example, the American chemical industry, which began to grow during World War I when the products of the German industry were cut off, stimulated a great demand for chemists. The rise of the atomic-energy program and a wide variety of other weapons involving the physical sciences, created, during World War II, a demand for physicists. The growth of the electronics industry and the magnitude of the defense program have maintained and even increased this demand since the war.

Dean Harrison points out that the number of chemists, now about 80,000, has been doubling every 10 years; while the number of physicists, now about 20,000, has been doubling every 8 years. The number of biologists, now about 30,000, is increasing at a slower rate. The rate of increase in the number of persons trained in a field is some indication of the amount of activity in that field. These figures suggest that physics is at present in its greatest period of development, while biology has still to reach its peak activity level.

There are dangers, of course, in using empirically derived estimates as definite program goals for planning purposes. On the other hand such estimates reflect long-term trends which tend to change slowly. For this reason they have some validity in indicating the general order of magnitude of the problems which will have to be dealt with.

The President's Materials Policy Commission's emphasis upon our diminishing natural resources in the face of an expanding economy suggests cogent reasons why increasing dependence will be placed upon scientists and technologists. World War II, to be sure, and the tensions of the postwar world have emphasized shortages in certain skills, but it seems certain that whatever the political situation, our technology will continue to expand at an increasing rate, either to create the machines of war, or, more happily, for peacetime purposes. In any event, future needs for scientific and technical manpower are almost certain to be far greater than those we now find difficult to meet.

LOSS OF STUDENTS AT THE BACCALAUREATE AND UNDERGRADUATE LEVELS

A large portion of the most capable graduating college-seniors in science never enter upon graduate study. Part of the reason is economic. The student weighs the costs of three or four years of graduate study against the attractive salaries he finds he can command upon graduation. Engineers and physicists with 4 years of undergraduate training are now offered salaries of from $3,000 to $6,000 a year. College graduating classes are besieged with personnel representatives, so that most students have a choice of jobs upon graduation.

As the number of baccalaureate graduates in science decreases, it is important to consider what fraction of these graduates are capable of pursuing graduate study and becoming research scientists. Studies supported by the Foundation and conducted by the Office of Scientific Personnel of the National Research Council and by the National Scientific Register clearly show that despite unprecedented amounts of financial support for graduate students in the postwar period, many capable students desirous of continuing their training have been unable to do so because of lack of finances.

The National Research Council reports that of approximately 70,000 graduating college seniors who majored in science in 1952, about 14,400 (20 percent) were judged capable of continuing graduate work toward the doctorate degree. Of these 6,400 (44 percent) will receive full support from family or personal sources, fellowships, assistantships, or G. I. benefits. Another 3,400 (24 percent) have partial support which may be sufficient to enable them to begin graduate training. Some 1,200 seniors, although judged capable of pursuing graduate studies, apparently have no desire to continue. The remaining 3,400 desire to continue advanced scientific training but have no support.

As was pointed out previously the National Science Foundation is emphasizing first-year awards of graduate fellowships to help as many students as possible across the bridge between undergraduate and graduate study.

RESEARCH EDUCATION IN THE SCIENCES

The number of students entering the colleges in all fields is estimated at 40 percent of those capable of doing college work. The anticipated rate of attrition during the 4-year undergraduate period is about 50 percent. Under these conditions, the role of the college teacher in developing, as fully as possible, those who remain takes on added significance.

A preliminary inquiry by the National Science Foundation has uncovered very few analyses of the problems associated with college-level teaching of science. Many educators agree, however, that no single factor is so important in influencing the choice of a science career as the student-teacher relationship. A joint study conducted by the Bureau of Labor Statistics and the Office of Naval Research of occupational mobility of scientists bears out this point. The histories of holders of Ph. D.'s in chemistry, physics, and biology, show that interest in the branch of science in which these men later specialized began most often in the junior year in college. It was also found, that four out of five had majored as undergraduates in the branch of science in which they are currently competent.

If a teacher is to inspire and stimulate his students with the desire to pursue research careers, it seems clear that he himself must appreciate research. He must be aware of significant developments in his field and be able to communicate to his students the excitement and interest in new developments as they occur. This in turn means that he must keep in touch with research progress and enjoy at intervals a chance to do research or to form fresh associations with other research scientists, preferably away from his home campus. The Foundation is, therefore, assisting in developing methods for increasing the effectiveness of teaching at institutions of higher learning and increasing the quality of training in the sciences.

The Office of Scientific Personnel, National Research Council, has shown that 46 percent of all graduate students receiving doctorates in science during the decade 1936–45 did their undergraduate work at institutions which did not award scientific doctorates during that period. This demonstrates that small colleges are an effective factor in production of scientists. Moreover, over half of this group received their training from only 118 of the eleven hundred smaller institutions of higher learning in the United States. It is apparent from these figures that only one out of ten of these small institutions is effectively turning out potential scientists.

Under its program of research education in the sciences the Foundation will assist selected teachers of science to spend their summers or a year of absence at research and training centers. During this interval the recipients will be able to associate closely with leading scientists and accomplished teachers of science. In addition, plans are under way for establishing a limited number of summer research centers or colloquia to aid teachers of science in keeping informed of new developments in their fields through research or training.

INFORMATION ON SCIENTIFIC MANPOWER

Concurrently with the passage of the National Science Foundation Act of 1950 a register of scientific and technical personnel was established and supported initially by the National Security Resources Board. Shortly thereafter, the Foundation assumed financial responsibility for the National Scientific Register. At the same time it undertook a study under the direction of Dr. Dael Wolfle, of the Commission on Human Resources and Advanced Training, Conference Board of Associated Research Councils, as to how best to carry out its statutory directives to provide a central clearinghouse for information covering scientific and technical personnel. The study was completed in June 1952.

The report listed four primary purposes for collecting information on scientific and technical manpower:

1. To provide the basis for statistical studies of the supply of and national demand for scientists and specialists.
2. To aid in administrative planning.
3. To serve as a basis for compilation and publication of scientific biographical directories.
4. For employment and placement purposes.

The National Scientific Register served primarily as a means for compiling data on personnel, and by the end of 1952 it will have completed the initial registration and analysis of data on scientists in chemistry, chemical engineering, physics, psychology, agricultural and biological sciences, geosciences, and veterinary medicine. The Register was not used for employment and placement purposes, and statistical studies were limited in nature. On the other hand, the report indicated that a number of scientific societies had for years maintained registers of scientists in their respective fields, and many societies conducted placement services.

In these areas there appeared to be no justification for the Federal government to set up competing facilities beyond those necessary for the coordination of the efforts of private groups. This has been the basic policy adopted by the Foundation in carrying out its manpower clearing-house functions.

In line with this policy, the operation of the present National Scientific Register will be discontinued after December 31, 1952. An office has been established by the Foundation to assist the professional scientific societies in compiling information on the scientists in various fields on a uniform basis. The individual societies will be encouraged to maintain placement and employment services. For special studies and general planning purposes extensive use will be made of sampling techniques.

In undertaking the register and clearing-house function the Foundation will be greatly aided by the wartime experience with the National Roster of Scientific and Specialized Personnel and by the experience of the Office of Education and Bureau of Labor Statistics in conducting surveys of scientific manpower. The Foundation is also cooperating with other Federal agencies in this program and is giving careful attention to their needs.