Science Graduate Students and Their Support

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FELLOWSHIP PROGRAMS IN THE SCIENCES have burgeoned in the past ten or fifteen years, and particularly since the recent war, because educational and industrial groups recognize the ever-increasing need for competently trained scientists. New fellowship programs are also being proposed under federal auspices, as in the current Science Foundation legislation. What the extent of such programs should be, in order to meet the need for additional support, is uncertain, because fellowship offerings could conceivably be too plentiful. New programs should not offer so many opportunities as to lead to lowered standards in American educational institutions. Furthermore, too many additional appointments might upset the traditional pattern of using graduate students as instructors for undergraduate courses. While some change in this pattern might be desirable, a major shift would create serious administrative problems in the universities. Many hold that fellowship offerings should be adequate to assist all interested students who have demonstrated genuine ability. What this order of magnitude might be, however, has not been determined heretofore, for lack of enough information on the number of graduate students and their means of support.

To throw light on the need for fellowship support, the Office of Scientific Personnel of the National Research Council undertook in the late spring of 1948 to collect information from colleges and universities on their enrollments in the sciences for the academic year 1947–48. Questionnaires were distributed directly from the Office of Scientific Personnel to colleges not granting advanced degrees, soliciting information on those students graduating with a science major in 1948, and on junior science majors. For information from institutions granting advanced degrees, questionnaires were distributed through the professional societies in the various fields, with two exceptions. Chemistry was omitted because the American Chemical Society had recently distributed a questionnaire on enrollments and engineering because the percentage of engineering graduates going on to advanced work is smaller than in other fields so that the OSP questionnaire would not have been suitable.

Response was sufficient to indicate that reasonably reliable over-all estimates could be drawn from the information obtained. The four-year colleges responding were generally those that have furnished most of the students going on to advanced study, as judged by the number who have taken advanced degrees in science. On this basis, the responding colleges represent about 80 percent of the graduating scientists in institutions which have produced successful graduate students in the past.

The number of universities responding varied for different sciences; in each field the return was from the head of the department to the cooperating professional society. By comparing the number of doctorates granted by these institutions with the total number of degrees granted in each field for the corresponding year, it was possible to judge the percent of the population covered and so arrive at good estimates of national totals.

An independent check on the data is the U. S. Office of Education survey of graduates with science majors for the school year 1947–48. The totals for the number of graduating science majors estimated by the two independent surveys agree within 8 percent. The Office of Scientific Personnel survey is admittedly less representative of the very small colleges which have graduated few science majors in the past, because the response was less satisfactory from such schools. This accounts, in part, for the fact that the Office of Scientific Personnel total is about 8 percent less than that of the U. S. Office of Education. Since only an order of magnitude was desired, however, the agreement seems satisfactory; also, the distribution of science majors by fields has been determined.

The distribution of B.S. science majors given by the U. S. Office of Education is as follows:

Agriculture and agronomy	5,112	Geology	1,097
Anatomy	111	Mathematics	4,106
Bacteriology	556	Pharmacy	1,975
Biology	6,306	Physics	1,923
Botany	337	Physiology	131
Biochemistry	473	Psychology	5,916
Chemistry	7,183	Forestry	810
Entomology	35	Zoology	2,036

The Office of Education total of B.S. graduates with science majors in 1948 is 38,107. The OSP total is 35,099 after applying a factor to adjust for nonresponding schools. Therefore, the figure of 36,000 will be used, since the Office of Education figure includes many institutions where science majors may represent low concentrations in the field.

The questionnaire of the OSP differed from that of the Office of Education in that it asked for information on plans of the students and certain judgments concerning competence. The heads of departments were asked to state the number of their students who were deemed qualified to go on to advanced degrees. The estimate was uniformly more flattering for the four-year colleges than for the universities, for while university department heads estimate that only about 17 percent of their graduating majors are clearly doctoral degree timber, the heads of departments in the colleges estimate that about 25 percent are so qualified. One can assume this means either that the four-year colleges have more competent students or that their faculties are perhaps less critical in their judgment. For the purposes of this study, the smaller percentage (17 percent) has been used. This percentage of the number of graduating science majors (using a figure between the Office of Education figure and the OSP figure) amounts to approximately 6,100 seniors who are deemed good doctoral candidates in the judgments of their teachers. Slightly more than one-third this number, however, did not intend to go on for graduate work in the sciences because of other interests and opportunities, so that there were left about 3,800 science majors who desired to go on to graduate work in the sciences and were apparently very able. It is interesting to compare this figure with the number of science doctorates granted in the United States in 1948—approximately 1,750.

About 20 percent of all graduates in the sciences were planning to begin advanced work soon after graduation. Those who graduated from universities seemed to have an advantage over those who graduated from four-year colleges; 10 percent of the science majors from universities were expecting support of a scholarship or fellowship not requiring services, whereas less than 1 percent from the four-year college expected to receive such scholarship aid. Almost half of those from universities who were planning to start graduate work were receiving support requiring services, while only 38 percent from the colleges were receiving such support.

Of those judged competent to go on for a doctoral degree, about 25 percent would not be able to for lack of financial support, the percentage being approximately the same for graduates of the different types of institutions. Since, as we have noted, there were about 3,800 1948 science graduates who had the desire and the ability to go into advanced work, it appears that about 1,000 fellowships for the first year of graduate work would be necessary to insure these able students an opportunity to study. It should be remembered that the class of 1948 was larger than prewar classes and may not be typical.

In the returns on graduate enrollments, the major group omitted is chemistry. Some idea of the totals in that field, however, can be obtained by noting that chemistry majors were about 21 percent of all science majors at the B.S. level in 1948. Chemistry doctorates were about 32 percent of all science doctorates in 1946, 27 percent in 1947, and 28 percent in 1948. It is probable, therefore, that chemistry graduate students constitute roughly one-fourth of the graduate population in the sciences.

Table 1 shows that about 80 percent of all graduate students are carrying one-half or more of a full-time training schedule. These are probably all resident students on the campus; Table 2 indicates the type of support they receive. The remaining 20 per-

TABLE 1

DISTRIBUTION BY FIELDS, TYPES OF APPOINTMENTS, AND TYPES OF TRAINING SCHEDULES

Sciences	Total number of students	Average hours per week worked by nonresearch appointees	Percent carrying more than half full-training schedule	Percent carrying half full-training schedule
Agriculture and agronomy	1,014	19	50.7	24.1
Anatomy	82	14	41.5	12.2
Botany (including ½ biology)	637	15	58.4	28.2
Entomology	139	14	55.4	44.5
Forestry	55	14	87.2	3.6
Genetics	99	15	57.6	31.3
Geology	1,029	15	65.5	18.0
Horticulture	223	16	42.6	29.6
Mathematics	2,345	10	48.7	19.8
Pharmacology	94	16	54.3	37.2
Physics	3,214	14	54.2	23.9
Physiology	170	12	66.0	19.4
Psychology	3,256	14	66.5	18.7
Zoology (including ½ biology)	734	11	67.1	22.8
All sciences	13,091	13.4	57.8	21.8

cent are probably off-campus students, employed full-time elsewhere.

The total percentage of persons receiving support, exclusive of veteran benefits, according to this table, is 66.4. There may be some overlapping in the various categories because some students are receiving simultaneously two or more types of support, such as fellowships and teaching assistantships. Analysis of the numbers in the different categories indicates that such overlap is probably not great. It will be noted, however, that nearly half of all graduate students are receiving G. I. benefits, which obviously overlap other types of support in a great percentage of cases.

Table 3 shows the number of graduate students in American universities in the various sciences aside from chemistry and engineering. As pointed out before, about 21 percent of the graduating science majors at the baccalaureate level in 1948 were chemists, and about 28 percent at the doctoral level in 1947 and 1948. It seems safe, therefore, to adjust the total of 18,000 shown in the table by adding one-third, making a total of 24,000 science graduate students aside from engineering. This may be compared with the total of 36,000 science majors graduating from college in 1948, 20 percent of whom indicated they intended to enter graduate school. It will be noted that the faculties estimate that 8,451, or 47 percent of the graduate enrollment (exclusive of chemistry), are likely to complete the doctorate. According to this estimate, the number of doctorates in five years adjusted to include chemists rises to approximately 11,400 or 2,280 per year. Some graduate students enrolling later than 1948 may also achieve a doctorate in this period and would add to the figure. However, 47 percent of all graduate students achieving a doctorate seems an unduly high estimate and the average given seems unlikely to be exceeded. The annual rate of granting doctorates in American universities approximately doubled each decade up to the peak year of 1941, and if this rate of increase had continued there would have been 4,000 doctorates granted in 1951. It appears that this rate of training is far in the future.

A recent report is of interest in this connection. In the January 1949 issue of *The Educational Record,* published by the American Council on Education, there is an article by C. Gilbert Wrenn, reporting on studies made at the University of Minnesota under the auspices of the Associated Research Councils and

TABLE 2

TYPE OF SUPPORT RECEIVED*

Sciences	Research appointments				Nonresearch appointments	Major fellowships		Minor fellowships		Veteran benefits
	% Reporting	% of Total enrollment	% of Column B on government contracts	% of Column B on industrial contracts	% of Total enrollment	% of Total enrollment giving no service	% of Total enrollment giving service	% of Total enrollment giving no service	% of Total enrollment giving service	% of Total enrollment receiving benefits
Agriculture and agronomy	72	31.4	4.0	11.6	10.1	12.0	8.1	3.3	9.8	51.7
Anatomy	43	28.1	43.4	No rep.	22.0	23.1	10.9	No rep.	12.1	32.9
Botany (including ½ biology)	82	20.6	9.9	10.6	35.9	10.9	9.7	2.9	14.4	39.2
Entomology	27	21.6	23.3	33.3	24.4	5.7	2.1	0.7	20.1	50.3
Forestry	14	16.3	No rep.	33.3	36.4	3.6	9.0	7.2	9.0	83.6
Genetics	44	36.4	No rep.	No rep.	14.2	4.0	19.1	1.0	5.0	46.4
Geology	85	6.4	4.5	12.1	32.6	7.7	10.0	5.9	12.9	67.7
Horticulture	64	29.6	No rep.	7.5	13.9	2.6	17.9	3.1	7.1	35.4
Mathematics	98	2.5	61.0	No rep.	28.6	4.0	9.6	1.9	11.5	31.3
Pharmacology	35	61.7	31.0	12.0	9.6	25.5	18.1	8.5	14.8	36.1
Physics	70	17.6	93.6	1.9	32.2	5.0	9.7	3.0	10.5	40.6
Physiology	28	31.7	31.4	11.1	16.4	8.2	18.8	7.6	24.1	45.8
Psychology	86	6.2	43.0	7.0	14.6	4.1	5.6	2.4	5.0	43.9
Zoology (including ½ biology)	52	11.3	30.1	7.2	35.1	4.0	10.5	4.3	15.3	34.3
All sciences	72.3 A	13.0 B	47.7 C	7.6 D	24.9 E	6.1 F	9.3 G	3.0 H	10.1 I	43.5 J

* All figures adjusted to 100% response. All averages are weighted averages.

based on information partly supplied by the Office of Scientific Personnel. It indicates a median score on an I.Q. scale of 141 for a large sample of persons who achieved a doctorate in the sciences. It also indicates that, at this level of ability, about one-third of the population does not finish college. This suggests that the number of highly qualified persons who might go on to advanced training if they had the necessary incentive and opportunity may be as high as 50 percent of those now completing college.

TABLE 3

DISTRIBUTION AMONG THE VARIOUS SCIENCES AT DIFFERENT LEVELS OF TRAINING*

Sciences	% Reporting	Adjusted totals enrolled	% First year enrollment	% Second year enrollment	% Accepted for or working on doctoral dissertations	Number considered likely to achieve doctorate in 5 years
Agriculture and agronomy	72	1,408	49.6	30.8	28.9	769
Anatomy	43	190	47.9	38.9	47.9	116
Botany (including ½ biology)	82	777	38.5	37.7	47.6	507
Entomology	27	515	42.3	51.1	33.8	344
Forestry	14	393	52.7	43.5	18.0	164
Genetics	44	225	39.5	39.5	34.2	115
Geology	85	1,211	45.0	40.9	25.8	515
Horticulture	64	348	57.5	36.8	22.4	169
Mathematics	98	2,393	48.4	29.5	12.2	699
Pharmacology	35	269	48.7	34.9	38.2	206
Physics	70	4,591	42.3	32.9	24.6	2,226
Physiology	28	600	50.0	35.2	32.7	317
Psychology	86	3,786	56.5	26.9	24.2	1,664
Zoology (including ½ biology)	52	1,411	47.3	34.2	29.8	640
All sciences	72.3	18,117	47.9	32.9	25.6	8,451

* Figures reported are as of April 1, 1948, but are adjusted to represent 100% reporting.

The questionnaire asked how many additional students could be accepted for graduate training. From the replies, it appears that substantial numbers of students can yet be accommodated in all fields. About twice as many can be accepted for classroom training as for work requiring facilities for laboratory research. However, only half as many additional candidates for the doctorate in theoretical research can be accepted as in experimental research. This latter situation varies greatly from field to field.

An interesting piece of information brought out by the questionnaire is the clear indication of interest in postdoctorate fellows. Respondents reported that they could and would like to entertain almost ten times as many postdoctorate fellows as they now have.

In summary then, it may be said that information furnished by colleges and universities indicates a total of approximately 6,000 graduates at the bachelor's level in 1948 who are judged competent to achieve a doctorate in the sciences. Of these, about 4,000 are interested in going on to graduate work and about 1,000 of these do not have financial support.

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