OCCUPATIONAL MOBILITY OF SCIENTISTS

A STUDY of
CHEMISTS
BIOLOGISTS
and PHYSICISTS
with PH.D. DEGREES

Bulletin 1121

UNITED STATES DEPARTMENT OF LABOR
Martin P. Durkin, Secretary

BUREAU OF LABOR STATISTICS
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In Cooperation with
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LETTER OF TRANSMITTAL

United States Department of Labor,
Bureau of Labor Statistics,
Washington, D.C., February 25, 1953.

The Secretary of Labor:

I have the honor to transmit herewith a report on the occupational mobility of chemists, biologists, and physicists, holding Ph.D. degrees. The study was conducted in the Bureau's Division of Manpower and Employment Statistics in cooperation with the United States Department of Defense. The coordinating agency of the Department of Defense was the Manpower Branch, Human Resources Division, Office of Naval Research.

The study was conducted and prepared by Theresa R. Shapiro.

Ewan Clague, Commissioner.

Hon. Martin P. Durkin,
Secretary of Labor.

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INTRODUCTION

The study of occupational mobility can have a wide variety of purposes. It may contribute to the development of a realistic theory of wages, the measurement of social class fluidity,or an analysis of the adjustment of the supply of labor to changes in demand. In the present mobilization period, interest in mobility studies centers mainly on the information they may provide regarding the actual and potential supply of qualified workers in key occupations, such as the sciences or the skilled trades, and the sources from which additional workers can be recruited for fields of employment suffering from critical shortages of personnel. 1/

The present study is a first attempt at research on the mobility of scientists. Because it is a pilot study, the aim has been to explore as many different aspects of mobility as possible and to test a variety of analytical approaches. The sample is both small and selective and the study does not yield definitive answers to the complicated problems of the supply and recruitment of scientists. It has been possible,however, to reach broad conclusions concerning the extent to which Ph.D. scientists shift from one specialty to another, between different types of scientific functions, kinds of employers, and parts of the country.

1/ Other studies being carried on by the Bureau of Labor Statistics cover such occupations as tool and die makers, molders, and electronics technicians.

This report begins with a summary of the findings and conclusions. The scope and method of the study is presented in the second chapter. The third chapter analyzes the extent to which scientists shift between scientific fields, the fields in which they are employed when they transfer, the value of scientists' reports of their fields of highest competence as an indication of their experience in different specialties, and the part which graduate and undergraduate majors play in scientists' careers. The fourth and fifth chapters are devoted to transfers among functions and types of employers. These sections of the report deal with such questions as: In what kind of work does a Ph.D. scientist normally begin his professional career? Does such work influence his subsequent experience? Are scientists stereotyped as teachers, research men, government employees, or do they move freely among these activities and types of employers? The report concludes with a discussion of scientists' geographic mobility, both as students and as employees, and of the net effect of their geographic movements in terms of personnel gains and losses for the areas in which they received their education.

Summary and Conclusions

Scope and Method.--This pilot study analyzes the greater part of the work histories of 1,122 Ph.D.'s in chemistry, physics, and biology, who constituted about 5 percent of the Nation's Ph.D.'s in each of these fields at the time of the survey in 1948. The analysis covers the first professional position, the current one, and the two intermediate jobs of longest duration. The employers for whom the scientists had worked on these jobs represented slightly more than four-fifths of all those with whom they had held full-time positions.

Scientists were considered to have changed jobs when they shifted their field of specialization, type of activity, employer, or State of employment, because this approach facilitated the analysis of various types of mobility considered in this report. Hence, the number of employers recorded was smaller than the number of jobs (an average of 2.9 employers compared with 3.2 jobs per scientist).

Transfers Between Fields of Specialization.--Studies of occupational mobility have disclosed a fairly close relation between the amount of training required to enter an occupation and the degree of attachment to it: unskilled and semiskilled workers tend to change occupations rather frequently, but skilled workers and professional people are characterized by a high degree of occupational stability. In view of the long specialized training Ph.D. scientists receive, it would be expected that their careers would be concentrated within limited scientific areas. Nevertheless, three-fifths of the biologists and chemists in the study (for whom this information could be recorded) had some experience outside the specific specialty (i.e., organic chemistry, bacteriology) in which they were currently employed. Moreover, one out of four specialists in all three sciences covered by the study had at sometime worked in an entirely different discipline. Physics had drawn a higher proportion of men from other sciences than either biology or chemistry. More than a third of the men working in physics had experience in another science, compared with 22 percent of those in biology, and 15 percent of those employed in chemistry.

However, when all the jobs in the study are considered together, it is seen that such experience covered only minor parts of the scientists' work histories. Not more than a third of the jobs recorded for the men working in chemistry had been outside the branch of chemistry in which they were working at the time of the study, and only a fourth of all the jobs recorded for the biologists fell outside the particular branch of biology in which they were currently employed. Among scientists employed in several specialties--namely, organic chemistry, biochemistry, botany, and entomology--the proportion of jobs outside the specific specialty of current employment was lower than the average in the corresponding disciplines.

Fields of Competence as Indicators of Experience.--Because Ph.D.'s tend to specialize, the fields which they consider those of their highest competence are, in general, a good indication of their experience. All the scientists in the survey were asked to check, on a list of specialties, their fields of highest and second highest competence, because one of the main purposes of the survey of "American Men of Science" was the preparation of a roster of key scientists. A comparison of the fields of the jobs included in the study with the specific fields reported as of first and second competence showed only 4 percent of the jobs to be outside these areas. Close to two-thirds of all the jobs studied were within the specific field of highest competence.

Some of the scientists' experience outside their fields of highest competence represented nothing more than the first job adjustments of new graduates. Fifty-two percent of these first professional jobs, compared with 62 percent of all the jobs studied, were in the specific fields in which these scientists now consider themselves most competent. Some 16 percent of the first jobs, compared with 9 percent of all the recorded jobs, were in entirely different disciplines from those of the scientists' first specialties.

<u>The Role of Education in Determining Scientists' Specialties.</u>— For most of these scientists, the interest in the branch of science in which they had come to specialize was already developed when they entered their junior year in college. Four out of five had majored both as undergraduates and taken their Ph.D. degrees in the branch of science (chemistry, physics, or biology) in which they considered themselves most competent at the time of the survey.

For the 17 percent who shifted their major subject between the baccalaureate and the doctorate, the major for the higher degree usually proved to be the more important in later life. Fourteen percent, however, had changed their major when they became Ph.D. candidates and were still specialists in their Ph.D. field at the time of the study. Only 2 percent of the scientists had a field of highest competence and a bachelor's degree in the same science but a Ph.D. degree in a different field.

<u>Transfers Between Functions.</u>— Implicit in a doctor's degree is a mastery of techniques and a body of knowledge, which acts as a barrier to movement between scientific fields, but which facilitates shifts among different kinds of work within a particular area of specialization. The two principal activities of the scientists in the sample were teaching and research: At the time of the survey, 38 percent were college teachers, 30 percent were doing research, and 21 percent were in technical administration, which normally include both research and supervisory duties. Many of the college teachers (more than 40 percent of those for whom three or four jobs were recorded) had at sometime worked as research scientists. The obverse is also true; more than a third of the research scientists (with three or four jobs within the scope of the study) and 42 percent of the comparable group of technical administrators had at sometime held regular college teaching posts.

For 30 percent of the scientists in the sample, a third kind of work was also recorded. In many cases this experience was gained on the man's first professional job. A third of all the scientists began their careers as assistant college teachers or laboratory assistants. Another 16 percent had started out either in inspection testing or similar routine professional work or as high school teachers.

<u>Transfers Between Types of Employers.</u>—As would be inferred from the transfers between teaching and research, most of the scientists had worked for at least two different types of employers. Three-fifths of all the scientists and three-fourths

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of the group for whom four employers were recorded had experience in at least two different types of employment.

An analysis of the transfers between types of employers from the first to the second recorded job and from the third to the fourth indicates that educators were less likely to change their type of employer despite the relatively low salaries paid by colleges and universities. About half the Government employees stayed in the Government, less than two-thirds of the private-industry scientists continued in private industry, but nearly three-fourths of the educators remained on the campus. Moreover, the largest proportions of those who left either Government or private industry entered educational institutions. The scientists' decisions to remain in or enter university employment was probably influenced as much by the kind of alternatives available to them as by a preference for this type of employment. A lower proportion of the chemists (who have wide opportunities in industry) than of either biologists or physicists, remained on the campus in these shifts.

Geographic Mobility.--Scientists begin their geographic movements while they are still students. More than 60 percent of the approximately 12,000 Ph.D. biologists, chemists, and physicists included in the Biographical Directory of American Men of Science obtained their bachelor's and doctor's degrees in different States: More than half obtained their baccalaureates and doctorates in entirely different sections of the country.

The scientists continued to migrate after they had completed their education. More than 40 percent of all the scientists in the sample on which this study is based and close to two-thirds of those with four jobs studied had worked in at least three different States. A comparison of these figures with those shown for the geographic movements of other occupations indicates that Ph.D. scientists are one of the most mobile segments of the population.

As would be expected in view of the high geographic mobility of the scientists, only a fourth were currently employed in the States where they had received their bachelor's degrees, and only one out of three was employed either in the State of his baccalaureate or that of his doctorate.

Regional Gains and Losses Between Education and Current Employment.--Certain regions of the country, notably the North Central and Middle Atlantic States granted many more doctorates than baccalaureates to the scientists, according to data for all the chemists, biologists, and physicists with Ph.D. degrees. On the other hand, many more baccalaureates than doctorates were awarded in the South. This tendency for graduates of southern colleges to go to northern schools for their graduate work has been a cause of concern in the South. This study shows, however, that Ph.D. scientists do not necessarily work in the section of the country in which they receive their doctor's degrees. The number of scientists employed in the North Central States, at the time of the survey, was not only less than the number who had received doctor's degrees from North Central universities, but also less than the smaller number who had earned baccalaureates in the region. The opposite was true for the South. More of these Ph.D. scientists were working in this region in 1948 than had received baccalaureates there.

Conclusions.--In summary, the study indicates that, despite the employment stability of Ph.D. scientists, they must be characterized as a relatively mobile group in certain respects. By the time they reach middle age, a large proportion have had experience in at least three of the functions normally performed by scientists. Most of them--whether educators, government employees, or employees in private industry--have worked for at least one other type of employer. The majority have held positions in two or more States. Moreover, more than half have transferred at some time from one scientific specialty to another.

These findings have certain implications for personnel planning in the sciences.

1. Geographic location need not be a limiting factor in planning research and development programs, at least with reference to the recruitment of scientists, particularly Ph.D.'s. Scientists are usually willing to move to a new locality in order to advance their economic or professional interests.

2. The personnel supply in a particular branch of chemistry or biology may be substantially augmented through transfers from other branches of these respective disciplines. However, no sizable number of persons can be expected to shift from one major discipline to another.

3. Since most Ph.D. scientists have had widely varied experience in the activities normally carried out by scientists,--teaching, research, technical administration, etc.--the number engaged in a particular type of activity at any specific time is no indication of the number qualified to carry on this kind of work. Above all, many more Ph.D.'s have had experience in research than are actually employed in this kind of work at any given time.

SCOPE AND METHOD

The Scientists Studied

This study is a byproduct of a 1948 mail questionnaire survey which had two major purposes; the establishment of a roster of key scientists, for use by the Department of Defense, the National Research Council, and other agencies concerned with the supply of scientific personnel; and the provision of information for the 1949 edition of the Biographical Directory of American Men of Science. A report on the educational background, recent employment, and earnings of the scientists in the Directory has already been published. 2/ The present study is based on an analysis of the work histories reported in the questionnaire of a sample group of men chemists, physicists, and biologists with Ph.D.'s.

The sample was restricted to scientists in three fields because the inclusion of a larger number of disciplines would have required an analysis beyond the scope of this pilot study. Women were excluded because a separate study of their job movements would have been necessary, in view of the special factors affecting their employment, and there were too few women in the group from whom the sample was drawn to permit such analysis. Scientists without Ph.D.'s were omitted because the Directory included only a small group of such scientists, who were presumably equal to Ph.D.'s in scientific attainment and therefore in no way representative of all the country's scientists with bachelor's and master's degrees. On the other hand, the Ph.D.'s in the Directory comprised a large proportion (about two-thirds) of the Nation's scientists at this level of training. It is believed that, by taking a sample of this group, a good cross-section of all male Doctors of Philosophy in the studied sciences has been obtained. 3/

Altogether, the study includes 1,122 men who had earned the Ph.D. degree by mid-1948, who were employed at the time they returned their questionnaires, and who reported their field of highest competence as some branch of physics, biology, or chemistry.

2/ Employment, Education, and Earnings of American Men of Science, Bulletin No. 1027, U. S. Department of Labor, Bureau of Labor Statistics, 1951. Prepared in cooperation with the U. S. Department of Defense, Washington, D. C., 1951. A reproduction of the questionnaire, on which the present study is based, is attached to the back cover of that report.

3/ See Bulletin No. 1027, U.S. Department of Labor, op.cit., p. 4 , for a discussion of the coverage of the Biographical Directory of American Men of Science.

The chemists were by far the largest group in the sample, 55 percent; the biologists were the next largest group, 30 percent. Although the physicists constituted only 15 percent of the sample, they represented about the same proportion (approximately 5 percent) of the Nation's professionally active Ph.D.'s in their field as did the sample groups of chemists and biologists. 4/

The criterion used in deciding whether a scientist should be classified in one of the three fields covered by this report was his own opinion as to his field of highest competence. In filling out the questionnaire, each respondent was asked to check, from a list of about 600 fields of specialization, the one in which he considered himself most competent. All the men included in this study checked a branch of chemistry, physics, or biology. This means that some scientists with Ph.D. degrees in these fields were excluded because they no longer considered themselves primarily biologists, physicists, or chemists. It means also that 8 percent of the men in the sample were employed in fields other than biology, physics, or chemistry in mid-1948, when they filled out their questionnaires, although they still regarded one of these sciences as their first specialty (table 1).

Table 1.--Fields of current employment of the scientists in the study, 1948

Field of current employment	Number	Percent
Total reporting	1/1,066	100.0
Chemistry	549	51.5
Physics	142	13.3
Biology	293	27.5
Medicine and related fields	7	.7
Engineering	16	1.5
Earth sciences	3	.3
Agriculture	10	.9
Mathematics	5	.5
Metallurgy	2	.2
Electronics	3	.3
General science	15	1.4
Other	21	1.9

1/ Excludes 56 scientists for whom only 1 job was recorded. This was coded as the first rather than the current job in order to facilitate the entire analysis.

In selecting the questionnaires for inclusion in the present study, it was not possible to utilize random sampling techniques. However, the scientists in the sample were compared with all the Ph.D.'s in these fields as described in Bulletin No. 1027 with respect to several key characteristics--median age and distribution by type of employer and by region of employment. This comparison indicates that, with regard to these characteristics at least, the men in the sample were representative of all Ph.D.'s in the given sciences.

The median age of the scientists in the sample was 40 years. The chemists and physicists had median ages of 39 and 41 years respectively, identical with the medians for all Ph.D. chemists and physicists in the Directory. 5/ The biologists in the sample had a median age of 42 years, only slightly lower than that for all Ph.D. biologists (43 years).

4/ The Bureau of Labor Statistics estimated the number of professionally active Ph.D.'s in each of these fields by applying appropriate death and retirement rates to figures of the number of doctorates granted in each of these subjects between 1912 and 1948.

5/ Bulletin No. 1027, U.S. Department of Labor, op. cit., p. 11. It should be noted that, in the age tabulations in that study, physicists were grouped with electronics scientists, some of whom were probably engineers.

The sample also followed closely the larger group from which it was drawn in the proportion of scientists working in each type of employment (table 2). In both the larger and smaller groups, about half the chemists were currently employed in private industry and about a third were working on the campus. 6/ On the other hand, university employment predominated among the physicists and biologists. In biology, three-fifths of the Ph.D.'s both in the sample and the Directory were employed in educational institutions, and about a tenth were in private industry. An even higher proportion of the physicists in the sample, more than two-thirds, were employed in education. Among all Ph.D. physicists in the Directory, the proportion working for educational institutions may have been slightly lower than this, but it was above 60 percent.

6/ Ibid., p. 44. There are some differences between that study and the present one in the method of classifying employment; hence, exact comparisons between the two studies concerning the proportion of Ph.D. scientists employed by each type of employer are not possible.

Table 2.—Types of employers for whom scientists were working, by field of highest competence, 1948

Type of employer	All scientists	Field of highest competence		
		Chemistry	Physics	Biology
	Percent			
Educational institution ...	46.8	33.1	67.5	60.5
Government	13.7	9.6	8.0	23.7
Private industry	35.5	53.5	20.2	11.9
Independent consultant	.7	.5	1.8	.3
Self-employed	.5	.7	—	.3
Nonprofit foundation	2.8	2.6	2.5	3.3
Total	100.0	100.0	100.0	100.0
Total number reporting	1/ 1,066	574	163	329

1/ Excludes 42 chemists, 3 physicists, and 11 biologists for whom only 1 job was recorded. This was coded as the first rather than the current job in order to facilitate the entire analysis.

Table 3.—Region of current employment of scientists in the study and of all Ph.D. chemists, biologists, and physicists, 1948 1/

Region of current employment	Scientists in this study		All Ph.D. chemists, biologists, and physicists 1/	
	Number	Percent	Number	Percent
Total	2/ 1,066	100.0	13,197	100.0
New England	72	6.8	947	7.2
Maine, New Hampshire, Vermont	9	.9	139	1.1
Massachusetts, Rhode Island, Connecticut	63	5.9	808	6.1
Middle Atlantic	425	39.8	5,063	38.4
New York, New Jersey, Pennsylvania	301	28.2	3,784	28.7
Maryland, Delaware, District of Columbia	124	11.6	1,279	9.7
South	144	13.5	1,854	14.0
Virginia, West Virginia, Kentucky, North Carolina, Tennessee	60	5.6	781	5.9
South Carolina, Georgia, Alabama, Mississippi	31	2.9	328	2.5
Florida	9	.9	153	1.1
Arkansas, Louisiana, Oklahoma, Texas	44	4.1	592	4.5
North Central	238	22.3	3,083	23.4
Ohio, Indiana, Illinois, Michigan	187	17.5	2,405	18.2
Minnesota, Iowa, Wisconsin	51	4.8	678	5.2
Mountain and Plains	75	7.1	816	6.2
Nebraska, Kansas, Missouri	35	3.3	402	3.1
North Dakota, South Dakota, Montana, Idaho, Wyoming, Colorado, Utah, Nevada	25	2.4	317	2.4
Arizona, New Mexico	15	1.4	97	.7
Pacific	100	9.4	1,350	10.2
Washington, Oregon	22	2.1	300	2.2
California	78	7.3	1,050	8.0
Territories and foreign countries	12	1.1	84	.6

1/ The data for all Ph.D. chemists, biologists, and physicists is based on Bulletin No. 1027, U. S. Department of Labor.
2/ Excludes 56 scientists for whom only 1 job was reported.

The geographic distribution of the scientists in this study likewise corresponded closely with that of all Ph.D.'s in the same fields (table 3). Fifty-seven percent of both the sample group and the scientists from whom this group was selected were employed in the Middle Atlantic and East North Central States at the time of the survey (table 3). The southern states ranked third as a region of employment, with 14 percent of both men in the sample and all Ph.D. chemists, physicists, and biologists.

Measurement of Mobility

Much of the available information on the occupational mobility of scientific personnel comes from studies which cover only a fraction of the respondents' work experience, although it is widely recognized that the ideal study would trace entire work histories. The difficulty of gathering reliable information covering all of an individual's work experience is one reason the work-history approach has been neglected. An equally serious obstacle is the tabulation and presentation of such data. The complexity and difficulty of tabulations on occupational mobility increase in geometric ratio with the number of jobs which are considered per individual.

Another difficult problem encountered in every study of occupational mobility is the definition of "job" and "job change." It goes without saying that when a person changes employers he also changes jobs. But the number of employers for whom a man works does not necessarily indicate the entire extent of his mobility. People are also shifted from one research problem to another, are promoted, or are transferred to a different plant or department. In the present study, a job was defined as a continuous period of employment with one employer, in one field of specialization, with one type of activity, and in one State. This definition was dictated by the purpose of the study--to analyze scientists' mobility not only between specialties and types of employers, but also between functions and geographic areas.

The present study attempted to approximate the work histories of these scientists and at the same time keep the work of tabulation within the bounds of feasibility by limiting the analysis to a maximum of four jobs per scientists--the first professional job after completion of college, the position held at the time of study, and the two intermediate jobs of longest duration. Furthermore, only full-time jobs which had lasted at least 3 months were studied. 7/

7/ Part-time work such as consulting or night-school teaching (which supplemented full-time jobs), summer and other jobs of less than 3 months' duration, and research fellowships were excluded from the analysis. With these exceptions, four employers were recorded for every scientist who had worked for four or more employers. Hence, in some cases only part of the employment (the assignment of longest duration) with one or more of these employers was analyzed.

Not all the scientists in the sample had held four jobs as defined by the study. Fewer than four jobs were recorded for 45 percent of the men; only one or two jobs for 22 percent. The average number of jobs recorded was 3.2 per scientist (table 4).

Because the study was not limited to a specific time period and included men of all ages, the number of jobs recorded for a scientist was inevitably influenced by his age and years of experience. The men for whom four jobs were recorded were the oldest group in the study, with a median age of 42 years, compared with a median age of 40 years for those who had held three jobs, and 37 years for those for whom one or two jobs were recorded. Even among the men past 50, however, there were some (17 percent) who had never changed their specialization, locale, or even the kind of activity they performed (table 5). Moreover, even among the youngest men in the study, those under 30, more than a third had held four jobs, as defined by the study. Thus, the number of jobs recorded for a scientist was in itself an indication of his employment mobility.

Table 4.--Distribution of scientists according to number of jobs and number of employers included in the study

Number of jobs	Percent of scientists				
	Total	Number of employers			
		One	Two	Three	Four
1 job	100.0	100.00	--	--	--
2 jobs ...	100.0	18.78	81.22	--	--
3 jobs ...	100.0	3.92	26.27	69.81	--
4 jobs ...	100.00	1.63	8.79	27.85	61.73

It follows from the definition of "job" used in this study that two or more jobs were recorded for some scientists who had worked for only one employer. For example, a chemist who had been the group leader in charge of developing a new product in the central laboratory of a large company was put in charge of the pilot plant set up in another city for the further development of the product, and later became manager of the plant in still another city where the product was put into mass production. For the purpose of this study, that chemist had held three jobs as he worked in three different localities, although he continued to work for the same employer. There was a considerable number of such cases. Thirty percent of the scientists who had held three jobs had worked for only one or two employers, and 38 percent of those for whom four jobs were recorded had worked for fewer than four employers (table 4). The average number of employers for whom the men had worked on the jobs included in the study was 2.9. Since, this figure is only moderately lower than the average of 3.2 jobs per scientist, it is obvious that most of the mobility considered in this study involved a change of employers, rather than a shift merely in work assignment or work location.

In order to evaluate the study's coverage of the scientists' entire work experience, a comparison was made of the number of employers for whom the scientists had worked on the jobs included in the study with the total number for whom they had ever worked on a full-time basis. This comparison indicated that the scientists in this study, like most professional people, had a high degree of employment stability, and also

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Table 5.—Age of scientists, by number of jobs included in the study

Age group	All scientists	Scientists having specified number of jobs: One job	Two jobs	Three jobs	Four jobs
	Number				
All ages	1/ 1,114	54	196	254	610
Under 30 years	86	12	20	23	31
30 - 34 years	244	12	63	60	109
35 - 39 years	223	11	45	48	119
40 - 44 years	197	5	24	49	119
45 - 49 years	130	5	17	26	82
50 - 54 years	97	4	13	23	57
55 - 59 years	81	3	11	12	55
60 - 64 years	30	1	2	8	19
65 - 69 years	22	—	—	5	17
70 years and over	4	1	1	—	2
	Percent				
Under 30 years	7.7	22.2	10.2	9.1	5.1
30 - 34 years	21.9	22.2	32.1	23.6	17.9
35 - 39 years	20.0	20.3	23.0	18.9	19.5
40 - 44 years	17.7	9.3	12.3	19.3	19.5
45 - 49 years	11.7	9.3	8.7	10.2	13.4
50 - 54 years	8.7	7.4	6.6	9.1	9.4
55 - 59 years	7.3	5.5	5.6	4.7	9.0
60 - 64 years	2.7	1.9	1.0	3.1	3.1
65 - 69 years	2.0	—	—	2.0	2.8
70 years and over	.3	1.9	.5	—	.3
Total	100.0	100.0	100.0	100.0	100.0
Median age	40	37	37	40	42

1/ Excludes 8 scientists who did not report age.

that the study covered a large proportion of the scientists' full-time employment. The scientists, whose median age was 40 years, had worked for an average of 3.5 employers from the time of their first job until the time of the survey. 8/ Moreover, three-fourths of the men had worked for four or fewer employers. It follows that this study, though limited to four jobs per scientist, covered most (slightly more than 80 percent) of the employers for whom the scientists had ever worked on a full-time basis (table 6). Further, an examination of the questionnaires indicated that much of the excluded employment was in short-term work, particularly summer school teaching.

8/ The relative employment stability of professional personnel is also shown in a study of occupational mobility in six cities, based on a sample of the entire working population in these areas. The study indicated that on the average the people in all the technical and professional occupations combined had worked for 1.9 employers in the 10-year period 1940-49. The study also showed that there was a much higher degree of employer mobility at the lower skill levels and that for the most mobile group in the population, the laborers, the average number of employers in the decade was 2.8 per individual. See Mobility of Workers in Six Cities, an unpublished report of the Industrial Research Department, Wharton School of Finance and Commerce, University of Pennsylvania.

Table 6.--Total number of employers for whom scientists had worked and proportion of these employers covered by the study

Total number of employers	Scientists in the study		Employers covered by study	
	Number	Percent	Number	Percent of all employers for whom scientists had worked
Total reporting	1,122	100.0	3,224	1/ 81.0
1 employer	114	9.9	114	100.0
2 employers	246	22.0	488	99.2
3 employers	262	23.4	758	96.4
4 employers	212	18.9	769	90.7
5 employers	133	11.9	490	73.7
6 employers	73	6.5	284	64.8
7 employers	40	3.6	155	55.4
8 employers	25	2.2	98	49.0
9 employers	14	1.3	56	44.4
10 employers	3	.3	12	40.0

1/ Employment in summer jobs, other jobs of less than 3 months' duration, and research fellowships were excluded from the analysis. Therefore, some of the employers for whom the scientists had worked on a full-time basis were not covered by the study, even in the case of scientists who reported no more than 4 employers.

TRANSFERS BETWEEN FIELDS OF SPECIALIZATION

Are highly trained scientists so specialized that they function only in a limited scientific field, or are they sufficiently flexible to transfer easily from one field of specialization to another in response to changing economic and social requirements? This is the principal question to which a study of the occupational mobility of scientists must address itself.

The answer to this question given by any study is inevitably greatly influenced by the way in which scientific fields are defined and classified. The complex and interrelated world of science can be subdivided into almost any number of different specialties. These specialties may also be grouped into a few broad disciplines. Obviously, a study which considered only shifts between broad disciplines would tend to show fewer occupational transfers than one which analyzed movements between narrowly defined scientific fields.

The present report analyzes scientists' movements from one broad field of science to another and also between the major subdivisions of these disciplines. For convenience, biology, chemistry, physics, engineering, and other broad scientific fields are referred to in this report as "general fields" of specialization, and subdivisions of the general fields are designated "specific fields" of specialization. 9/ The specific fields, into which chemistry was divided, are general chemistry, organic chemistry, inorganic chemistry, analytical chemistry, physical chemistry, and biochemistry. Biology was divided into the traditional fields--general biology, botany, bacteriology, entomology, and zoology. For technical reasons it was not possible to subdivide physics. A complete list of the general and specific fields considered in this report is given in the appendix (p. 54). 10/

9/ The more common term "discipline" is used as a synonym for "general field of specialization" throughout the report. In the same way, the term "specialty" is used interchangeably with "specific field of specialization."

10/ It will be noted in this list that some of the specific fields are broader than others. For example, both geology and pharmacy are classified as specific fields whereas mathematics is considered a general field of specialization. The classification of specialties used in this study was, perforce, the one developed for the original questionnaire, which was not constructed for the purpose of studying occupational mobility. However, the problem of coding fields of specialization in such a way as to equate areas of equal scope on the same digital level has never been completely solved, and is probably not susceptible of complete solution.

Most Ph.D. scientists work in specialties still narrower than the specific fields used in this report. For example, more chemists work as specialists in plastics and other synthetics than in organic chemistry as a whole. Many more zoologists work in invertebrate zoology than in general zoology. Precise information as to a scientist's narrow specialty cannot be obtained for each job he has held by means of a questionnaire survey. Hence, the present study does not attempt to study shifts between detailed areas of specialization. Such information was obtained, however, by means of interviews, for about 400 Ph.D. chemists, physicists, and biologists. An analysis of these interviews is now in preparation.

The Number of Fields in Which the Scientists Had Worked

The extent to which Ph.D. scientists shift between scientific disciplines is shown in table 7, which gives the number of general fields of specialization in which the 1,122 reporting scientists had worked in the course of the jobs included in the study. One out of four had at sometime worked in a different general field from that in which he was currently employed. The proportion was highest in physics and lowest in chemistry. More than a third of the men working in physics (37 percent) had experience in another science, compared with 22 percent of those employed in biology and only 16 percent of those in chemistry. These figures suggest that the rapidly expanding field of physics has drawn on other sciences for its personnel to a greater degree than has either chemistry or biology. The most mobile group in the study, however, were not the men currently employed in physics but the scientists (8 percent of the total) working in fields other than chemistry, biology, or physics at the time of the survey. Four out of every five of them had worked in more than one general field. Very few men, even in this small group, had worked in as many as three different general fields.

In some instances, experience in a second general field reflected a broadening of interest rather than a change of specialty.11/ The promotion of a professor of biology to the chairmanship of a science division was recorded as a shift from biology into general science, even though the particular scientist continued to give some courses in biology. In some other cases, the recorded transfer represented a scientist's shift from research into

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11/ A scientist was considered to be doing scientific work even when he was engaged in an administrative capacity, provided that he supervised a group of scientists or administered a research program. If, however, his duties involved the business administration of an organization or the management of a production unit, he was classified as working in a nonscientific field. As shown in table 9 few of these scientists had any experience in nonscientific fields.

Table 7.--Number of general fields of specialization in which scientists were employed on jobs included in the study

Field of current employment and number of jobs	Total number of scientists reporting	Percent of scientists			
		Total	Employed in specified number of general fields		
			One	Two	Three
All fields	1,122	100.0	75.0	24.1	0.9
1 job	56	100.0	100.0	--	--
2 jobs	197	100.0	90.5	9.5	--
3 jobs	255	100.0	81.7	17.5	.8
4 jobs	614	100.0	65.1	33.6	1.3
Chemistry	589	100.0	84.1	15.2	.7
1 job	42	100.0	100.0	--	--
2 jobs	118	100.0	95.8	4.2	--
3 jobs	150	100.0	85.0	13.6	1.4
4 jobs	279	100.0	76.5	22.8	.7
Physics	147	100.0	63.0	35.6	1.4
1 job	3	(1/)	(1/)	--	--
2 jobs	21	100.0	85.7	14.3	--
3 jobs	28	100.0	63.0	37.0	--
4 jobs	95	100.0	56.8	41.1	2.1
Biology	306	100.0	78.4	20.6	1.0
1 job	11	100.0	100.0	--	--
2 jobs	47	100.0	91.5	8.5	--
3 jobs	71	100.0	85.7	14.3	--
4 jobs	177	100.0	70.6	27.7	1.7
Other	80	100.0	16.3	82.5	1.2
1 job	--	--	--	--	--
2 jobs	11	100.0	36.4	63.6	--
3 jobs	6	(1/)	(1/)	(1/)	--
4 jobs	63	100.0	11.1	87.3	1.6

1/ Number too small to warrent calculating percentages. Because, however, the study used a small sample, percentages were calculated for small totals in this and the following tables, provided these figures were more than 10. This was done to give the reader some idea of the distribution in each case, even though the percentages as such have no significance.

managerial work, as a plant manager for instance, rather than active participation in a different scientific field. For most of the scientists, however, work in a second science involved either teaching or research experience in this second field.

Table 8 shows the number of specific fields in which the scientists had worked, the second or third field lying either within the general field of his current employment or in a different discipline. Almost 60 percent of the chemists and biologists combined had worked in two or more specific fields of specialization, and 15 percent in three or more fields.

By subtracting the figures in table 7 from the corresponding figures in table 8, a comparison can be made of the relative frequency of intra- and interdiscipline shifts. As would be expected, a larger number of scientists had worked at sometime in different branches of the general fields in which they were currently employed than had crossed over into different disciplines. Only 16 percent of the chemists had worked outside chemistry, but 42 percent had experience in two or more branches of that science. A smaller proportion of the biologists than of the chemists had made intradiscipline shifts, probably because the major branches of biology are less closely related to each other than is the case in chemistry. Nevertheless, 33 percent of the men working in some branch of biology at the time of the survey had experience in another branch of that field, compared with 22 percent who had been employed outside biology.

Experience outside the field of a man's current employment is less significant as an indication of potential mobility if such experience is limited to his first professional job than if it comes at a later stage in his career. First jobs are often so limited in scope that the experience gained in them is by no means an indication of competence in the specialty involved. It is important to note, therefore, that for the majority of the scientists who had experience in a second field of specialization, this experience was not confined to the first professional job. Two-thirds of the men who had worked in a second general field had gained part or all of that experience in an intermediate job. Experience in a second discipline was confined to the first job for only a third of all the scientists with such experience. The finding with respect to experience outside the specific field of current employment is much the same. About 60 percent of the scientists who had worked outside the specialty in which they were employed at the time of the survey had gained part or all of that experience after completing their first professional job.

The fact that experience in a discipline outside the current and usual field of employment was by no means confined to first job adjustments is also indicated by a comparison of the number of fields in which the scientists had worked with the number of jobs recorded for them. Only 10 percent of the scientists for whom two jobs were recorded had experience in more than one general field. This proportion increased to 18 percent for the men with three studied jobs, who were on the average

Table 8.--Number of specific fields of specialization in which scientists were employed on jobs included in the study

Field of current employment and number of jobs	Total number of scientists reporting	Percent of scientists				
		Total	Employed in specified number of specific fields			
			One	Two	Three	Four
All fields	1,122	100.0	43.5	41.7	13.5	1.3
1 job	56	100.0	100.0	--	--	--
2 jobs	197	100.0	72.9	27.1	--	--
3 jobs	255	100.0	44.2	45.8	10.0	--
4 jobs	614	100.0	28.6	48.5	20.5	2.4
Chemistry	589	100.0	42.2	43.2	13.4	1.2
1 job	42	100.0	100.0	--	--	--
2 jobs	118	100.0	75.8	24.2	--	--
3 jobs	150	100.0	39.9	50.0	10.1	--
4 jobs	279	100.0	20.3	54.4	22.8	2.5
Physics	147	100.0	63.0	28.8	8.2	--
1 job	3	(1/)	(1/)	--	--	--
2 jobs	21	100.0	85.7	14.3	--	--
3 jobs	28	100.0	63.0	25.9	11.1	--
4 jobs	95	100.0	56.8	33.7	9.5	--
Biology	306	100.0	45.6	40.6	12.5	1.3
1 job	11	100.0	100.0	--	--	--
2 jobs	47	100.0	70.2	29.8	--	--
3 jobs	71	100.0	48.6	41.4	10.0	--
4 jobs	177	100.0	34.5	45.8	17.5	2.2
Other	80	100.0	10.0	57.5	27.5	5.0
1 job	--	--	--	--	--	--
2 jobs	11	100.0	27.3	72.7	--	--
3 jobs	6	(1/)	(1/)	(1/)	--	--
4 jobs	63	100.0	6.3	52.4	35.0	6.3

1/ Number too small to warrant calculating percentages.

3 years older than the former and to 35 percent for the oldest group in the sample, the men who had held at least four jobs (table 7). This tendency for an increasing number of scientists to gain experience in a second discipline with a longer stay in the labor market applied equally to the biologists, chemists, and physicists. The same tendency is also shown in the data on transfers between specific fields (table 8).

Patterns of Transfer Between Specialties

Although a considerable proportion of the scientists in this study had worked at sometime outside their field of current employment, their experience in other specialties usually represented only a small part of their employment histories. This is shown by an analysis of the fields in which 1,122 scientists had worked on 3,613 jobs covered by the study. All but 12 percent of these jobs were in the same general fields as the scientists' current jobs (table 9). The proportion of jobs outside the general field of current employment was higher (15 percent) for the men working in physics than for those in chemistry or biology (7 and 8 percent respectively) confirming the points made in the previous section that there is a greater tendency for scientists to shift into physics than into either chemistry or biology.

Work outside the scientists' specific field of current employment bulked larger in their work histories than employment in other broad scientific disciplines. About a third of all the jobs recorded for the men working in chemistry and a fourth of those held by the biologists were in specific fields other than the ones in which these scientists were employed at the time of the study (table A, p.55). 12/ These previous positions were widely scattered among a variety of specific specialties, and only a small percent were in any one field. In the case of the men currently working as organic chemists, for example, 74 percent of all the recorded jobs were in organic chemistry, 17 percent in general chemistry, and not more than 2 percent in any other specific field.

Because of the small number of jobs recorded as outside the scientists' field of current employment, the data do not permit definite conclusions as to patterns of transfer between specialties. Insofar as

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12/ This percentage varied widely among specialties—from a low of only 15 percent for the botanists to a high of 41 percent for the general biologists. It should be noted, however, that these differences among specialties were, in some measure, the result merely of the difficulties encountered in classifying jobs by field. If a scientist did not give enough information in his questionnaire to determine the branch of chemistry or biology in which he had worked on a given position, or if his work covered more than one branch of biology or chemistry, this job was classified under "general chemistry" or "general biology." The effect of this procedure was also to overstate somewhat the number of jobs recorded as in a different specific field from the one held at the time of the study.

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Table 9.—General fields of specialization in which scientists worked on all jobs included in study, by field of scientists' current employment

Field of scientist's current employment	Total number of jobs studied	Percent of all jobs studied which were in —												
		All fields	Chemistry	Physics	Biology	Medicine and related fields	Engineering	Earth science	Agriculture	Mathematics	Metallurgy	Electronics	General science	Nonscientific fields
Chemistry	1,806	100.0	93.3	0.9	1.5	0.2	1.2	—	0.3	0.6	0.1	—	1.5	0.4
Physics	499	100.0	4.6	84.8	1.2	—	2.2	0.4	—	1.0	—	2.0	2.4	1.4
Biology	1,009	100.0	1.3	.3	91.7	1.2	—	.1	2.1	.1	—	—	2.3	.9
Medicine and related fields.	26	100.0	26.9	—	19.2	53.9	—	—	—	—	—	—	—	—
Engineering	54	100.0	20.4	16.7	5.6	1.8	53.7	—	—	—	—	—	1.8	—
Earth sciences ...	11	100.0	18.2	27.3	—	—	—	54.5	—	—	—	—	—	—
Agriculture	37	100.0	—	—	40.5	—	—	—	59.5	—	—	—	—	—
Mathematics	17	100.0	—	35.3	—	—	5.9	—	—	58.8	—	—	—	—
Metallurgy	6	(1/)	(1/)	—	—	—	—	—	—	—	(1/)	—	—	—
Electronics	12	100.0	8.3	33.4	—	—	8.3	—	—	—	—	50.0	—	—
General science ..	53	100.0	17.0	7.5	28.3	—	—	—	—	—	—	—	37.8	9.4
Nonscientific fields	83	100.0	49.4	—	19.3	1.2	—	—	—	—	—	—	1.2	28.9

1/ Number too small to warrant calculating percentages.

there was any tendency for men currently employed in one field to have previous experience in some other specific field, the tendencies noted were very much what one would have expected. For example, physical chemists and analytical chemists were more likely to work as chemical engineers than were other chemists. Biochemists, on the other hand, worked more often in bacteriology and botany than in any other fields outside chemistry. Botanists shifted into agricultural sciences to a greater degree than did other biologists, whereas bacteriologists tended to shift into biochemistry and public health. Physicists more often worked in physical chemistry than in any other field of chemistry, and in electrical engineering rather than in any other branch of engineering. For all these scientists job experience in a nonscientific field was extremely rare (table A, p. 55).

Unlike the great majority of scientists who had spent most of their working lives in one specific field of specialization or in a closely related area, the small group who were not currently employed in chemistry, physics, or biology had worked in a wide variety of fields. Among them are found people with experience in such apparently unrelated fields as aeronautical engineering and biology, business administration and zoology, the liberal arts and organic chemistry, and manpower problems and biochemistry. Moreover, less than half of the jobs of this group were in the specific field in which the scientists were working at the time of the study.

It has been observed generally by students of labor mobility that a considerable part of the shifting reflected in average mobility rates arises from the movement of a small part of the population. 13/ In any occupational group, there are some people who do not change jobs at all within a given time span, some who make several changes, and some who fall between these extremes. It has not been possible in the present study to measure the degree of mobility of the individual scientists because the men in the sample were of different ages and had had different amounts of exposure to the labor market. The fact that a particular group of scientists showed a much higher degree of occupational mobility than the entire sample suggests, however, that, among Ph.D. scientists as among the general working population, there are wide individual differences in mobility.

It should be considered also that one criterion for including a scientist in the study was that he reported a field of highest competence in either biology, chemistry, or physics. Hence, some of the Ph.D.'s included in the Biographical Directory of American Men of Science, who held degrees in these subjects but who, by virtue of either recent or long experience in another area, no longer considered themselves primarily physicists, biologists, or chemists, were excluded from the sam-

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13/ For a discussion of the studies on labor mobility, see "Differential Short-Run Labor Mobilities," by Herbert L. Heneman, Jr., Minnesota Manpower Mobilities. Minneapolis, University of Minnesota Press, 1950, pp. 47-50.

ple. For example, one questionnaire was discarded in the course of the editing because the respondent, a Ph.D. in chemistry, had never worked as a chemist, but pursued a career as a concert pianist. Another respondent whose questionnaire was excluded also held a Ph.D. in chemistry and had worked as a research chemist for several years after receiving his degree. At the beginning of World War II he started to work in activities which required some knowledge of science but which were primarily administrative. After holding a series of administrative posts, he ceased to think of himself as a scientist, and reported his highest field of competence as nonscientific. Both examples illustrate the fact that some of the Ph.D. scientists who were most mobile, who had departed furthest from the fields of their training and early experience, were excluded from this study. A study of all people receiving Ph.D.'s in the sciences would show a higher degree of occupational mobility.

First and Second Specialties as Indicators of Experience

So far in this chapter, mobility has been studied with the current job as a point of departure. The study of mobility may also be, and frequently is, analyzed with the usual or normal occupation as a base point. This procedure has the advantage of grouping all the people who form part of the labor supply in a given occupation.

The concept of usual or normal occupation, however, is widely regarded as too broad for use in classifying scientific personnel, particularly in the development of rosters. Instead, the related concept, "fields of competence," has been devised to serve a two-fold purpose: the grouping of scientists and other professional people under the categories in which they are best qualified, and the summarization of their experience. It is thought also that the listing of people under their fields of highest competence brings into one category those who usually work in the same occupation.

An intimate knowledge of all the sciences and more detailed information on scientists' backgrounds than a mail questionnaire survey can yield are required to determine specialties with precision. For this reason, the device was developed of having the scientist himself choose his field of highest, second, and third-highest competence from a pre-coded list of specialties. The obvious limitation of this procedure is that it is subjective. The respondent, it has been argued, is not always the best judge of his own competence. Further, some registrants will check the fields in which they wish to work rather than the ones in which they have experience.

Up to now, the arguments for and against the "fields of competence" technique for roster registration have remained in the realm of speculation. The present study offered the first opportunity to discover whether the fields, designated by the scientists as those of their highest and second highest competence, are satisfactory indicators of their experience. This analysis shows the highest field of competence to be a useful shorthand for describing experience, at least for scientists with Ph.D. degrees.

As noted in the first chapter, each scientist in the study listed some area of chemistry, physics, or biology as his field of highest competence. Seventy percent of both the chemists and the biologists were employed in their specific fields of highest competence at the time of the survey (table 10). 14/ Most of the scientists also had worked in these fields on at least one previous job; 63 percent of the biologists and chemists combined, had held two or more jobs in their first specialty. About a third of the chemists and biologists had worked in their specialties on every job covered by the study.

Among the scientists for whom four jobs were recorded, a large proportion had worked in their specialty on at least three of these jobs. The proportion was higher in biology (58 percent) than in chemistry (44 percent). Moreover, more than one-fourth of the biologists and 13 percent of the chemists had always worked in the specific fields currently regarded as those of their highest competence.

Some of the scientists in the study apparently had never worked in their specific field of highest competence. In most cases, these were teachers who had taught either general courses or courses in more than one branch of their subject. Among the young men, of course, there were some who still considered the work on their Ph.D. thesis more significant than their subsequent jobs, and who listed their thesis field as their field of highest competence and their job field as that of second highest competence.

The field of second highest competence also played a part in the scientists' work histories, although a much less important one than the first specialty. This is seen in table 11, which shows that more than three-fifths of all the jobs included in the study were in the scientists' specific fields of highest competence and approximately another third in their fields of second competence. Together, the first and second specialties encompassed all but 4 percent of the jobs included in the study.

The proportion of jobs outside the first and second specialty combined varied considerably among scientists in different fields. It was

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14/ It will be recalled that specific fields of specialization were not recorded for physicists. A National Scientific Register survey of physicists in 1951 showed a similar proportion (65 percent) currently employed in the branch of physics which they had designated as their field of highest competence. Less than half (45 percent) the respondents in that survey had Ph.D.'s. These findings are incorporated in Manpower Resources in Physics, 1951, Scientific Manpower Series No. 3, Federal Security Agency, Office of Education, Washington, D.C., 1952.

Table 10.—Number of jobs scientists held in specific fields of highest competence

Field of highest competence and number of jobs	Total number of scientists reporting	Percent of scientists					
		Total	Number of jobs in specific fields of highest competence				
			None	One	Two	Three	Four
All fields	1,122	100.0	12.1	21.7	27.6	25.5	13.1
1 job	56	100.0	14.3	85.7	—	—	—
2 jobs	197	100.0	18.3	23.4	58.3	—	—
3 jobs	255	100.0	11.0	19.6	29.0	40.4	—
4 jobs	614	100.0	10.4	16.2	19.6	29.8	24.0
Chemistry	616	100.0	14.6	25.1	30.1	23.7	6.5
1 job	42	100.0	14.3	85.7	—	—	—
2 jobs	122	100.0	20.5	22.1	57.4	—	—
3 jobs	151	100.0	13.2	21.9	29.1	35.8	—
4 jobs	301	100.0	13.0	19.3	23.7	30.7	13.3
Physics 1/	166	100.0	6.6	10.3	24.1	27.1	31.9
1 job	3	(2/)	(2/)	(2/)	—	—	—
2 jobs	26	100.0	11.5	19.3	69.2	—	—
3 jobs	29	100.0	3.4	13.8	20.7	62.1	—
4 jobs	108	100.0	5.6	5.6	14.8	25.0	49.0
Biology	340	100.0	10.3	21.2	24.7	27.9	15.9
1 job	11	100.0	9.1	90.9	—	—	—
2 jobs	49	100.0	16.3	28.6	55.1	—	—
3 jobs	75	100.0	9.3	17.3	32.0	41.4	—
4 jobs	205	100.0	9.3	17.1	16.1	31.2	26.3

1/ It should be noted that physics was not further subdivided and is considered a specified field.

2/ Number too small to warrant calculating percentages.

Table 11.—Percent of jobs included in study which were in the scientists' fields of highest and second highest competence

Field of highest competence	Total number of jobs in study	Percent of jobs in: All fields	Specific field of highest competence	Specific field of second highest competence: Same general field as that of highest competence	Specific field of second highest competence: Different general field from that of first highest competence	All other fields
All fields	3,613	100.0	62.4	28.4	5.7	3.5
Chemistry	1,909	100.0	55.9	36.2	5.4	2.5
General	65	100.0	56.9	40.0	—	3.1
Analytical	136	100.0	50.8	48.5	.7	—
Biochemistry ...	227	100.0	69.2	18.5	9.7	2.6
Inorganic	129	100.0	38.0	49.6	8.5	3.9
Organic	830	100.0	59.6	39.7	.1	.6
Physical	522	100.0	49.8	31.6	13.0	5.6
Physics	566	100.0	1/78.6	—	13.4	8.0
Biology	1,138	100.0	64.5	29.4	2.2	3.9
Bacteriology....	183	100.0	60.1	27.3	7.1	5.5
Biology, general	247	100.0	47.0	46.6	.8	5.6
Botany	371	100.0	74.9	18.9	1.1	5.1
Entomology	184	100.0	74.5	25.0	.5	—
Zoology	153	100.0	60.8	35.3	3.3	.6

1/ This figure includes all jobs in any branch of physics, because this field was not further subdivided.

highest among the physicists (8 percent) who tended to be the most mobile group in the study and lowest (zero) among the entomologists. Even for the physicists, however, it is clear that the fields of highest competence are generally reliable indications of their work experience.

For purposes of classifying scientists in broader terms, the general field of highest competence is satisfactory, insofar as it is an excellent guide to the experience of most scientists. Ninety-one percent of all the jobs in the study were in the general fields in which the scientists considered themselves most competent (table 11). Even in the case of the physicists, a relatively high proportion of whom had entered that field from other sciences, less than a fifth of the recorded jobs were outside physics.

The Specialties of the First Jobs

The finding, that information on scientists' fields of highest competence serves as a good indication of their experience, is emphasized by the data on the specialties of their first jobs. A part of the scientists' limited experience outside their fields of highest competence was gained in their first professional positions (as shown by the figures presented below). Needless to say, initial experience is much less significant as an indication of competence in a given specialty than is later more advanced work.

Some new college graduates have

no clear-cut career aims; others are forced by circumstances to take the first jobs offered. Moreover, in past years, recent graduates were not always as eagerly welcomed by prospective employers as they have been during this period of defense preparations. For all these reasons, a relatively high proportion of the first jobs held by these scientists were in entirely different disciplines from those in which they later specialized--16 percent compared with 9 percent of all the jobs studied (table 12).

Somewhat different factors account for the sizable number of scientists who started out in the same general fields but different specific specialties from those in which they currently consider themselves most competent. These scientists often financed their graduate studies by working as laboratory assistants in the university departments in which they were taking their degrees. Many assistant teaching posts are for introductory courses, and the subjects taught in such a course may or may not be closely related to those in which the teaching assistant is specializing. Hence, a considerable number of fledgling Ph.D.'s in organic chemistry, for example, may find themselves teaching inorganic chemistry. Such circumstances are in some measure responsible for the fact that a higher proportion of the scientists' first jobs (48 percent) than of all their jobs (38 percent) were outside their specific fields of highest competence.

It should be noted, however, that 52 percent of the respondents were employed in their fields of highest competence at the outset of their professional careers. The study indicates that about one out of every

Table 12.--Comparison of scientists' field of highest competence with their field of specialization on first job

Field of highest competence	Total number reporting first job	Percent of scientists with first job in--			
		All fields	Specific field of highest competence	Different specific field but same general fields as that of highest competence	Other general fields
All fields	1/ 1,118	100.0	52.1	32.2	15.7
Chemistry	615	100.0	44.6	43.9	11.5
General	21	100.0	66.7	19.0	14.3
Analytical	41	100.0	36.6	46.3	17.1
Biochemistry	71	100.0	52.1	28.2	19.7
Inorganic	42	100.0	28.6	50.0	21.4
Organic	270	100.0	47.4	45.9	6.7
Physical	170	100.0	40.0	48.2	11.8
Physics	164	100.0	71.3	—	28.7
Biology	339	100.0	56.4	26.5	17.1
Bacteriology	54	100.0	40.8	33.3	25.9
Biology	71	100.0	42.3	38.0	19.7
Botany	113	100.0	73.5	8.8	17.7
Entomology	54	100.0	57.4	35.2	7.4
Zoology	47	100.0	53.2	34.0	12.8

1/ Excludes 4 scientists who did not report field of employment on first job.

Table 13.--Comparison of major subjects for doctor's and bachelor's degrees 1/

Major subject for Ph.D. degree	Total number reporting	Percent of scientists with bachelor's degrees in--				
		All subjects	Chemistry	Physics	Biology	Other
Chemistry ..	569	100.0	85.4	0.9	1.1	12.6
Physics	140	100.0	3.6	77.2	---	19.2
Biology	309	100.0	5.2	---	72.3	22.5
Other	42	100.0	16.7	2.4	23.8	57.1

1/ Excludes 20 scientists who did not report major subject of Ph.D., 33 who did not report major subject for bachelor's degree, and 9 who reported neither.

two Ph.D. scientists starts out and continues to work in the same specific field throughout the greater part of his professional life.

Role of Education in Determining Scientists' Specialties

Although most of these scientists had developed the interest that was to shape their lives by the time they were juniors in college, some changed their majors when they entered graduate school. There was also another much smaller group of scientists who, by the time of the survey, were no longer specialists in the fields in which they had taken their doctor's degrees.

Seventeen percent of the scientists earned their baccalaureates and their doctorates in different fields (table 13). For most of the scientists, however, the field of graduate study was closely related to the scientist's undergraduate major. True, 1 man had a bachelor's degree in architecture; another in business administration; 2 had begun in geology; and 18 had started out as students of the liberal arts. But the largest group of chemists who had not majored in chemistry as undergraduates had studied chemical engineering; the largest group of biologists with undergraduate majors outside the biological sciences had specialized in agriculture; and more physics recruits from other fields came from mathematics than from any other subject (table B, p. 57).

One reason why most of these scientists majored in the same subjects in both their graduate and undergraduate work is that they began their graduate studies either immedia-

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Table 14.--Scientists with bachelor's and doctor's degrees in same major subject, by interval between award of bachelor's and doctor's degree 1/

Number of years between receipt of bachelor's and of doctor's degree	Total number reporting	Percent of scientists		
		Total	With bachelor's and doctor's degree in--	
			Same subject	Different subjects
Total	2/1,069	100.0	83.2	16.8
Under 4 years	166	100.0	89.2	10.8
4 - 6 years	526	100.0	85.9	14.1
7 - 9 years	209	100.0	76.6	23.4
10 - 14 years	126	100.0	79.4	20.6
15 years or more	42	100.0	69.0	31.0

1/ For purposes of this table, the basis of comparison for the bachelor's and doctor's degrees was the general discipline, such as, chemistry, biology, and physics.

2/ Excludes 20 scientists who did not report date of Ph.D., 24 who did not report date of bachelor's degree, and 9 who reported neither date.

ately or shortly after they received their bachelor's degrees. Two-thirds of them earned their doctorates within 6 years after receiving the bachelor's degree. 15/ The longer the interval between the receipt of a baccalaureate and a doctorate, the greater the likelihood of a shift in the student's major field. The proportion of scientists who changed majors was only 11 percent for the group who obtained their doctorates within 3 years after bachelor's degree, in contrast to 31 percent for the men who waited 15 years or longer to take their doctorates (table 14).

For those men who had changed major subjects when they began graduate work, it was the graduate rather than the undergraduate major that more often played a determining role in the scientists' careers (table 14).

15/ A study of all the scientists who earned their doctorates between 1936 and 1948 showed that the modal time elapsed between the bachelor's and doctor's degree was 4 years, the median 6 years, and the mean 8 years. See "The Production of Doctorates in the Sciences: 1936-48." Washington, D. C., American Council on Education, 1951, p. 95.

Only 2 percent of the scientists were specialists, at the time of the study, in general fields in which they had majored as undergraduates but not as graduate students. On the other hand, 14 percent had altered their courses of study when they became candidates for the doctorate, and still regarded the general fields of their doctor's degrees as those of their highest competence (table 15).

In their decisions to transfer from one discipline to another, scientists are apparently influenced to some extent by the demand for personnel. Physics expanded much more rapidly than either chemistry or biology in the period immediately prior to 1948, the year when these data were obtained; and the men who classified themselves in 1948 as physicists were outstanding not only in the proportion who had earned their doctorates in a different field but also in the number who had first begun to specialize in physics as graduate students. More than twice as large a proportion of physicists (12 percent) as of biologists and chemists had taken their doctorates in a different general field from that of their highest competence. Moreover, a relatively larger number of physicists (20 percent) than of biologists and chemists (13 percent) had majored in that field only at the graduate level.

In most cases, Ph.D. candidates specialize in a particular branch of their general field. A graduate

Table 15.--Comparison of major subjects for bachelor's and doctor's degrees with scientists' general fields of highest competence

Field of highest competence	Total number reporting	Percent of scientists				
		Total	Major subject same as general field of highest competence			
			For both Ph.D. and bachelor's degrees	For Ph.D. only	For bachelor's degree only	For neither degree
All fields	1/1,060	100.0	79.9	14.2	1.9	4.0
Chemistry	578	100.0	81.6	14.2	1.4	2.8
Physics	154	100.0	68.2	19.5	1.3	11.0
Biology	328	100.0	82.3	11.9	3.1	2.7

1/ Excludes 20 scientists who did not report major subject for Ph.D., 33 who did not report major subject for bachelor's degree, and 9 who did not report major subject for either degree.

student of chemistry takes much of his work in one branch of chemistry. In the biological sciences, graduate work is almost entirely devoted to the major field of study. The question arises, therefore, as to the extent to which such highly specialized training is utilized by the scientists in later life.

A partial answer to this question is given in table C, p. 58. Most biologists remained in the specific field in which they had taken their doctorates. Eighty-five percent of the botanists, 94 percent of the entomologists, and 73 percent of the zoologists had received a doctorate in these respective fields. 16/ For technical reasons, the figures are less conclusive for the chemists, but it appears that few chemists specialize in a branch of chemistry other than that of their Ph.D. major. The largest group of chemists with training in a branch of chemistry outside their specific field of highest competence was found among the analytical chemists; 21 percent had majored for their doctorate in organic, inorganic, or physical chemistry, or in biochemistry.

Some Implications

The foregoing analysis has shown that Ph.D. scientists can and do transfer from one branch of a scientific field to another and even between disciplines, but that most of them spend the greater part of their working lives in one specialty or in a closely related field. One group of scientists in the study (the 8 percent not currently employed in chemistry, physics, or biology) showed a high degree of mobility. In addition, a small group of people with Ph.D.'s in the fields covered by the study whose activities had carried them so far afield that they no longer considered themselves primarily physicists, chemists, or biologists, were excluded from the sample. By and large, however, Ph.D. scientists are strongly attached to their fields of specialization.

No statistical analysis can indicate to what extent this attachment results from the attitudes of Ph.D. scientists toward their work and to what degree it is determined by the requirements of employers. The fact that most of the men chose their current specialties while still undergraduates suggests that the selection of these specialties expressed deep-rooted interests. Further, the minimum of 3 years of postgraduate study required for a Ph.D. degree represents too great a commitment to be set aside easily. It is well known, however, that once a professional person gains experience and competence in his field, he cannot transfer to another field except at some sacrifice of either prestige or earnings. The fact that a doctor of philosophy has a highly specialized training is in itself a barrier to occupational mobility.

16/ Reliance should not be placed on the relatively low proportion of bacteriologists (65 percent) who appear to have received a degree in that field. One important branch of that field, parasitology, is, for some purposes and in some schools, classified under zoology. This explains why 15 percent of the bacteriologists in this study had doctorates classified as in the field of zoology.

There is reason to believe that scientists with less academic training than Ph.D.'s have less attachment to a given field of specialization than do Ph.D.'s. A 1951 survey of physicists showed that 9 out of 10 Ph.D.'s had taken their highest degrees in this field, compared with 3 out of 4 holders of master's degrees and slightly more than two-thirds of those holding only bachelor's degrees. 17/ Moreover, only a fourth of all the scientists in the survey but close to half of those currently employed outside of physics held only bachelor's degrees. These findings suggest a close relation between the degree of attachment to a given scientific field and the extent of academic training in it. A study of occupational mobility which would include scientists at all levels of education would undoubtedly show a greater amount of occupational mobility than one, like the present, based on Ph.D.'s alone.

TRANSFERS BETWEEN FUNCTIONS

The analysis of the extent to which scientists shift from one kind of activity to another and the pattern of such movements requires a classification of the many kinds of work scientists do. This classification, like that of scientific specialties, involves problems of definition. What is the distinction between research and development? Where does routine analysis end and research begin? Where should the line be drawn between administration and other activities? These are some of the questions yet to be solved to the satisfaction of all or even a majority of students of scientific personnel.

In the present study, classification was determined by examining the information contained in the questionnaires and setting up as many categories of functions as could be distinguished. The following 16 categories were created: routine analysis and testing, and other routine professional work; design; development; research; technical administration; administration; college teaching; college teaching assistance (particularly laboratory assistance); other teaching (in elementary, secondary, technical, and vocational schools); sales and technical sales and service; technical writing; nontechnical editing and writing; wildlife management; extension work; and consulting.

A change in activity was recorded whenever a man's principal function shifted from one of the above-named types of activities to another. No analysis was made of secondary functions, such as part-time teaching or consulting, carried

17/ Manpower Resources in Physics, 1951, op.cit., p. 11.

Table 16.--Current functions performed by scientists in study, by field of highest competence, 1948

Current function	Percent distribution			
	All fields	Chemistry	Physics	Biology
College teaching	38.3	26.3	51.2	53.8
College teaching assistance	.4	.2	1.2	.6
Other teaching	.3	.5	—	—
Routine professional work	.1	—	—	.3
Research	30.0	34.0	27.7	23.5
Development	2.0	1.8	4.2	1.2
Design	.1	—	—	.3
Technical administration	20.5	28.0	10.3	11.7
Administration	4.5	5.0	3.6	4.1
Consulting	1.3	1.8	1.2	.6
Sales, technical sales, and services	.7	1.3	—	—
Estimating and cost analysis	.1	.2	—	—
Editing and writing	.1	.2	—	—
Technical writing	.3	.2	.6	.3
Extension work	.3	—	—	.9
Wild life management	.5	—	—	1.8
Other	.5	.5	—	.9
Total	100.0	100.0	100.0	100.0
Total number reporting	1,122	616	166	340

on along with other activities which occupied most of the scientists' time.

At the time of the survey, in 1948, more than half the biologists and physicists were employed mainly or solely as college teachers. Research was, however, the predominant activity of the chemists; close to two-thirds either were doing work classed as research or were employed as technical administrators, with responsibility for directing research activities. 18/ Only 5 percent of the scientists held administrative positions, 2 percent were in development, and less than 2 percent were engaged in any of the other list types of activities (table 16).

The Extent of Functional Mobility

An analysis of the activities carried out by scientists on the jobs studied suggests that Ph.D. scientists characteristically move from one type of activity to another. Four out of every five scientists in the sample had performed more than one of the functions listed above (table 17). Of the men who had held four jobs, three out of every five had worked in at least three different kinds of activities. Three-fifths of those who had held only two jobs had changed functions between these jobs.

18/ Technical administration was defined to include supervision of a group of scientists, direction of research activities, and liaison between the research division of an organization and other divisions. Persons with responsibility for business administration, production, or construction were called administrators as were college presidents and deans.

Some of these shifts in function represented progress up the promotional ladder. Since administrative jobs are usually obtainable only after long experience, it was among the scientists employed as administrators that the proportion who had performed in three or more different functions was highest (81 percent). 19/ Technical administration is usually an intermediate stage in professional advancement, and 54 percent of the technical administrators had three or more principal functions in the course of the jobs covered by the study. The relative numbers of college teachers and research scientists with experience in as many as three different functions were considerably smaller (30 and 24 percent, respectively), but high enough to indicate that only a part of the scientists' functional mobility was a reflection of professional advancement (table 18).

19/ The administrators were also the oldest group in the sample; their median age was 46 years compared with 38 years for the research scientists and 40 years for the entire sample.

Table 17.--Number of functions 1/ performed by scientists on jobs included in study

Field of highest competence and number of jobs	Total number of scientists reporting	Percent of scientists				
		Total	Number of functions performed			
			One	Two	Three	Four
All fields	1,122	100.0	19.3	41.8	31.5	7.4
1 job	56	100.0	100.0	--	--	--
2 jobs	197	100.0	41.8	58.2	--	--
3 jobs	255	100.0	14.1	53.7	32.2	--
4 jobs	614	100.0	7.0	35.6	44.0	13.4
Chemistry	616	100.0	20.2	41.9	29.9	8.0
1 job	42	100.0	100.0	--	--	--
2 jobs	122	100.0	38.3	61.7	--	--
3 jobs	151	100.0	14.6	51.0	34.4	--
4 jobs	301	100.0	4.9	35.5	43.4	16.2
Physics	166	100.0	15.7	37.3	39.8	7.2
1 job	3	(2/)	(2/)	--	--	--
2 jobs	26	100.0	36.0	64.0	--	--
3 jobs	29	100.0	10.7	60.7	28.6	--
4 jobs	108	100.0	10.0	26.4	52.7	10.9
Biology	340	100.0	19.7	44.1	30.6	5.6
1 job	11	100.0	100.0	--	--	--
2 jobs	49	100.0	52.9	47.1	--	--
3 jobs	75	100.0	14.5	56.6	28.9	--
4 jobs	205	100.0	8.9	41.1	40.6	9.4

1/ Such as college teaching, research, and consulting. For complete list see table 16.
2/ Number too small to warrant calculating percentages.

Table 18.--Number of functions performed by scientists on jobs included in study, by current function

Current function and number of jobs	Total number of scientists reporting	Percent of scientists: Total	Number of functions performed: One	Two	Three	Four
Total reporting	1,122	100.0	19.8	42.6	30.2	7.4
College teaching ..	431	100.0	22.2	47.7	24.8	5.3
Research	336	100.0	30.7	44.8	22.7	1.8
Development	22	100.0	13.6	36.4	40.9	9.1
Technical administration	228	100.0	7.0	38.6	40.8	13.6
Administration	52	100.0	--	19.2	59.6	21.2
Consulting	15	100.0	--	33.3	40.0	26.7
Other	38	100.0	10.5	29.0	44.7	15.8
One job	56	100.0	100.0	--	--	--
College teaching ..	21	100.0	100.0	--	--	--
Research	23	100.0	100.0	--	--	--
Other	12	(1/)	(1/)	--	--	--
Two jobs	197	100.0	42.9	57.1	--	--
College teaching ..	80	100.0	47.5	52.5	--	--
Research	76	100.0	50.0	50.0	--	--
Technical administration	31	100.0	19.4	80.6	--	--
Other	10	(1/)	(1/)	(1/)	--	--
Three jobs	255	100.0	14.5	53.5	32.0	--
College teaching ..	105	100.0	14.3	62.8	22.9	--
Research	87	100.0	25.3	47.1	27.6	--
Technical administration	43	100.0	--	46.5	53.5	--
Other	20	100.0	--	47.6	52.4	--
Four jobs	614	100.0	7.6	37.2	41.7	13.5
College teaching ..	225	100.0	9.7	43.4	36.7	10.2
Research	150	100.0	14.0	47.3	34.7	4.0
Development	10	100.0	--	20.0	60.0	20.0
Technical administration	146	100.0	1.4	29.5	47.9	21.2
Administration	40	100.0	--	10.0	62.5	27.5
Consulting	13	100.0	--	23.1	46.1	30.8
Other	30	100.0	6.5	25.8	48.3	19.4

1/ Number too small to warrant computing percentages.

Patterns of Functional Movement

Apart from transfers in functions which represented normal advancement from the lower to the higher professional grades, the most frequent shifts were between teaching and research (table 19). More than a third of the scientists who had held three or more jobs and who were currently engaged in research and technical administration had previously worked as regular college teachers, and more than 40 percent of the college teachers had at sometime worked as full-time research scientists. Movement between college teaching and research was somewhat less common in chemistry than in physics and biology.

Relatively few scientists had previous experience in work other than research and college teaching. About 7 percent of the scientists for whom three or four jobs were recorded and who were currently engaged in research, administration, and technical administration, and 5 percent of the comparable group of college teachers had experience in development. About 13 percent of the college teachers had taught in high school. A few of the biologists had experience in wild life management or in extension work. Seven percent of the physicists had worked as writers and editors. Only a handful in each scientific field had worked as sales and/or technical sales personnel, as designers, or as consultants (table 19).

Much of the scientists' experience outside of research, college teaching, technical administration, and administration was gained in their first professional positions. A third of the scientists had begun their careers as college teaching assistants, usually with responsibility for the laboratory in a few science courses. 20/ Next to work as a college teaching assistant, the most frequent first activity of these scientists was research, in which a fourth of the scientists had begun their careers. Another sizable group (20 percent) had started as full-fledged college teachers. Surprisingly few (9 percent) had started out in the traditional beginners' work of routine testing and analysis or routine classification. High school teaching, another occupation often regarded as transitional by the young men who start in it, had also engaged very few of these scientists at the onset of their careers (table D, p. 59).

There was some relation between the scientists' first job activities and their current ones. More than 70 percent of the college teachers but only about half the research scientists and technical administrators had been employed initially in a teaching position of some kind. More than twice as high a proportion of the research scientists as of the college teachers had started out in

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20/ Some men went back to school after having begun to work, and some of these financed their advanced schooling through assistant teaching posts. For this reason, a larger proportion had some experience in assistant teaching in the course of the studied jobs than was the case for the first professional position.

Table 19.—Comparison of previous functions with present function, for scientists with 3 or 4 jobs in this study

Field of highest competence and current function	Total number reporting	Percent with prior experience in 1/						
		Routine professional work	College teaching assistance	College teaching	Other teaching	Research	Development	Design
All fields:								
College teaching	2/ 331	10.6	52.3	66.5	13.0	43.2	4.5	—
Research	238	11.0	40.8	36.3	5.5	75.9	7.2	1.3
Technical administration	189	12.2	34.9	41.8	5.3	73.5	7.9	.5
Administration	49	8.2	24.5	57.1	4.1	49.0	6.1	—
Chemistry:								
College teaching	113	11.5	53.1	61.9	12.4	41.6	5.3	—
Research	137	10.9	48.2	27.0	3.6	73.7	7.3	2.2
Technical administration	140	14.3	37.1	34.3	5.7	76.4	8.6	—
Administration	31	9.7	29.0	41.9	3.2	51.6	6.5	—
Physics:								
College teaching	72	8.3	47.2	73.6	15.3	50.0	11.1	—
Research	37	2.8	45.9	47.2	8.3	77.8	16.7	—
Technical administration	13	—	30.8	76.9	7.7	92.3	—	—
Administration	6	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)
Biology:								
College teaching	146	11.0	54.1	66.4	12.3	41.1	.7	—
Research	64	15.6	21.9	50.0	7.8	79.7	1.6	—
Technical administration	36	8.3	27.8	58.3	2.8	55.6	8.3	7.7
Administration	12	—	25.0	83.3	—	58.3	—	—

Field of highest competence and current function	Technical administration	Administration	Consulting	Estimating and cost analysis	Sales, technical sales, and services	Editing and writing 4/	Extension work and wild life management	Other
All fields:								
College teaching	8.8	0.9	0.6	0.6	0.6	0.6	1.8	1.2
Research	11.0	—	.4	—	1.7	.4	1.7	1.3
Technical administration	27.5	2.1	—	.5	—	.5	1.1	2.1
Administration	46.9	8.2	2.0	—	6.1	2.0	2.0	4.1
Chemistry:								
College teaching	11.5	3.5	—	.9	1.8	—	—	1.8
Research	9.5	—	—	—	2.9	.7	—	.7
Technical administration	29.3	2.1	—	.7	—	—	—	2.1
Administration	58.1	9.7	3.2	—	6.5	—	—	6.5
Physics:								
College teaching	5.6	—	1.4	1.4	—	1.4	—	—
Research	16.7	—	—	—	—	—	—	5.6
Technical administration	15.4	—	—	—	—	7.7	—	—
Administration	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)	(3/)
Biology:								
College teaching	8.2	.7	.7	—	—	.7	4.2	1.4
Research	10.9	—	1.6	—	—	—	6.2	—
Technical administration	25.0	2.8	—	—	—	—	5.6	2.8
Administration	25.0	8.3	—	—	—	8.3	8.3	—

1/ The percentages in this table are in each case based on the total number of scientists shown in the first column, but are not mutually exclusive. That is, a scientist with experience in 3 different jobs was listed 3 times.

2/ Excludes 249 scientists for whom only 1 or 2 jobs were recorded and 66 with functions other than those shown.

3/ Number too small to warrant calculating percentages.

4/ Including technical writing.

research. A much higher proportion of the administrators than of any other group had started out as full-fledged college teachers. In considering these findings, however, it must be noted that some men whose first and current positions were both in teaching had held intermediate positions as research scientists. Likewise, some of the research scientists who had started out in this work had taught in a college at some point in their careers.

This analysis of changes in the scientists' principal functions takes no account of the sizable amount of part-time teaching by men engaged mainly in research nor the great volume of part-time research done by college teachers. A college teacher may have no contractual obligation to carry out a research project, but his standing in the academic community and his professional advancement depend to a great extent upon his research achievements and publications. It has been said that much of the difference between a research scientist and a university professor is that the latter chooses his research problem and the former has it chosen for him. This view represents only part of the truth: more of the Nation's research is done in industrial and government laboratories than on the campus. However, the findings of this study suggest that a professor of, for example, organic chemistry and a research chemist in that field have more in common than an organic and an inorganic chemist. Although Ph.D. scientists can and sometimes do transfer from one specialty to another, such movement is much less common than shifts in function, particularly between research and teaching.

TRANSFERS BETWEEN TYPES OF EMPLOYERS

Scientists have a high degree of mobility with respect to the types of employers for whom they work, as well as the functions they perform. This is shown in the present study, even though the categories used in classifying the organizations employing the scientists were broad. 21/ These were: education, government, private industry, nonprofit foundation, independent consulting work, and other self-employment. Three out of every five scientists in the study had held jobs in at least two of these categories (table 20). Of the scientists who had worked for four different employers in the course of the jobs studied, three-fourths had made one or more changes in type of employment: a sizable group (17 percent) had worked for three different kinds of employers, and a few had worked for a different type of employer on each of the four jobs.

The proportion of scientists who had always worked for one type of employer was much higher among those currently employed in education than among those in other fields--58 percent, compared with 20 percent (table 21). Moreover, differences in type-of-employer mobility among the groups in fields other than education were smaller than the difference between the educators and all the other scientists taken together. Apart from the extremely small number currently self-employed, the group of scientists who had been most mobile were the nonprofit foundation employees. Sixty percent of these employees had worked for two types of employers and 37 percent for three types. A higher proportion of scientists currently working for the government than of scientists in private industry had worked for two or more classes of employers, but this difference was partly due to the fact that the government employees tended to be older than the private industry scientists. 22/

21/ The extent of mobility recorded depends in part on the number of categories in a given classification system. Thus, for purposes of the present analysis, 5 type-of-employer categories were used, 16 function categories, 48 location categories (States), and an even higher number of specific specialties. It follows then that the probability, purely in terms of chance, that any given scientist would work for more than one type of employer was smaller than that he would work in more than one specialty.

22/ The median age of the government employees was 43 years, of the educators 41 years, and of the scientists in private industry 39 years.

Table 20.--Number of types of employers for whom scientists worked on jobs included in study

Field of highest competence and number of employers in study	Total number of scientists reporting	Percent of scientists				
		Total	Number of types of employers worked for			
			One	Two	Three	Four
All fields	1,122	100.0	41.0	49.7	9.0	0.3
1 employer	113	100.0	100.0	—	—	—
2 employers	279	100.0	50.5	49.5	—	—
3 employers	349	100.0	30.9	58.5	10.6	—
4 employers	381	100.0	25.5	56.7	17.0	.8
Chemistry	616	100.0	38.3	52.6	8.8	.3
1 employer	79	100.0	100.0	—	—	—
2 employers	159	100.0	47.8	52.2	—	—
3 employers	193	100.0	23.8	65.3	10.9	—
4 employers	185	100.0	18.9	62.2	17.8	1.1
Physics	166	100.0	45.8	43.4	10.8	—
1 employer	9	(1/)	(1/)	—	—	—
2 employers	39	100.0	53.8	46.2	—	—
3 employers	45	100.0	42.2	40.0	17.8	—
4 employers	73	100.0	37.0	49.3	13.7	—
Biology	340	100.0	43.5	47.7	8.5	.3
1 employer	25	100.0	100.0	—	—	—
2 employers	81	100.0	54.3	45.7	—	—
3 employers	111	100.0	38.7	54.1	7.2	—
4 employers	123	100.0	29.3	52.8	17.1	.8

1/ Number too small to warrant calculating percentages.

Table 21.—Number of types of employers for whom scientists worked on jobs included in study, by type of current employer

Field of highest competence and type of current employer	Total number of scientists reporting	Percent of scientists				
		Total	Number of types of employers worked for			
			One	Two	Three	Four
All fields	1/1,066	100.0	37.8	52.2	9.7	0.3
Educational institution	499	100.0	58.1	38.5	3.4	--
Government	146	100.0	15.1	68.5	15.7	.7
Private industry	379	100.0	23.7	64.1	11.9	.3
Self-employed 2/	12	100.0	--	33.3	58.4	8.3
Foundation	30	100.0	3.3	60.0	36.7	--
Chemistry	574	100.0	33.6	56.6	9.4	.4
Educational institution	190	100.0	53.9	42.4	3.7	--
Government	55	100.0	14.5	60.0	23.7	1.8
Private industry	307	100.0	27.0	65.2	7.5	.3
Self-employed 2/	7	(3/)	--	(3/)	(3/)	--
Foundation	15	100.0	--	53.3	46.7	--
Physics	163	100.0	44.8	43.6	11.6	--
Educational institution	110	100.0	59.1	39.1	1.8	--
Government	13	100.0	7.7	69.2	23.1	--
Private industry	33	100.0	18.2	51.5	30.3	--
Self-employed 2/	3	(3/)	--	(3/)	(3/)	--
Foundation	4	(3/)	(3/)	(3/)	(3/)	--
Biology	329	100.0	41.6	49.0	9.1	.3
Educational institution	199	100.0	61.8	34.2	4.0	--
Government	78	100.0	16.7	74.3	9.0	--
Private industry	39	100.0	2.5	66.7	30.8	--
Self-employed 2/	2	(3/)	--	--	(3/)	(3/)
Foundation	11	100.0	--	81.8	18.2	--

1/ Excludes 56 scientists for whom only 1 job was recorded.
2/ Includes independent consultants.
3/ Number too small to warrant calculating percentages.

A comparison also has been made of the types of employers for whom the scientists had worked on the first and second recorded jobs and on the third and fourth jobs. Well over half the scientists for whom information was available did not change their type of employer between the first and second jobs (table 22). This was true also for the third and fourth jobs (table 23). It should be noted, however, that a change in job, as defined in this study, did not always involve a change in the employing organization: about 19 percent of the scientists for whom a second job was recorded worked for the same organization on this job as on the first, and 38 percent of those for whom four jobs were recorded did not change employers between the last two jobs. If the analysis had been limited to job shifts which involved a change in employer, the percentage of shifts found to represent transfers from one type of employer to another would undoubtedly have been higher.

The conclusion indicated previously that college faculty members were the group least prone to shift to other types of employment is borne out by the scientists' movements between their first and second jobs and their third and fourth jobs. About 70 percent of those who had been educators before these job changes remained on the campus thereafter, but less than half of those who had been government employees stayed in government (tables 22 and 23). 23/ The scientists in private industry were more likely to remain in the same type of employment than were the government employees, but less apt to do so than the educators.

The figures in tables 22 and 23 also indicate that more than two-thirds of the scientists who left the government, private industry, or a foundation for another type of employment entered educational institutions. The largest numbers entering education from other types of employment came from private industry, but the proportion of government employees who left the government for education was higher than the corresponding proportion of private industry employees.

The fact that the universities were able to compete successfully with other types of employers in attracting and retaining scientists is noteworthy in view of the low salary

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23/ It should not be inferred that larger numbers of these scientists worked for universities on the second job than on the first or in the fourth job compared with the third. As between the first and second jobs, in fact, the absolute numbers employed in universities declined, because a certain number of scientists had been working as teaching assistants in order to finance their studies and severed their university ties when they obtained their doctorates. Even as between the third and fourth jobs, however, the number who entered the universities from other types of employment just about balanced the number who left the universities.

levels prevailing in educational institutions. 24/ Apparently, the advantages of university employment, such as freedom of research, are sufficiently strong to countervail, in the minds of many scientists, the economic handicaps such employment imposes. 25/

The extent of mobility and its direction is, however, as much a matter of economic opportunity as of personal preference. The decision to remain in university employment reflected, at least in some cases, nothing more than the lack of an alternative opportunity. Chemists, who are more widely used in industry than the other scientists, were the group who most often left universities for other types of employment. Less than two-thirds of the chemists but three-fourths of the biologists and physicists remained in education in the job changes recorded in tables 22 and 23. Moreover, most of the chemists who left education, and close to half of those who transferred out of government went into private industry. On the other hand, among the biologists who have limited opportunities for industrial employment, those who left educational institutions most often entered the government.

These figures give no information on the trends in the employment of Ph.D. scientists. That there has been an increase in the number of Ph.D. scientists in government and private industry is well known. These data suggest, however, that the recruits into government and industry have come in large measure from the ranks of the newly created doctors of philosophy rather than from among scientists already established as educators. 26/

24/ The median salary in 1948 of the Ph.D.'s employed exclusively in educational institutions was $4,860 a year, of those working solely for government agencies, $6,280; and of private industry employees, $7,070. Bulletin No. 1027, op.cit., p. 45. It does not follow, however, that the individual scientist who shifted into education suffered a reduction in earnings.

25/ A survey of a group of scientists who left government jobs in 1948 indicated that these scientists considered university employment on the whole the most desirable for technical work. See Clark D. Ahlberg and John C. Honey, Attitudes of Scientists and Engineers about their Government Employment, Syracuse University, 1950, Vol. 1, p. 40.

26/ That there has been a distinct tendency among the young Ph.D. scientists to go into research rather than into teaching is clear from the findings of two recent surveys of physicists and chemists, conducted by the National Scientific Register. See Manpower Resources in Physics, 1951, op.cit., and Manpower Resources in Chemistry, 1951, a forthcoming report by the U. S. Department of Labor, Bureau of Labor Statistics and the National Scientific Register.

Table 22.--Types of employers for whom scientists worked on second job in study compared with type of employer on first job

Field of highest competence and type of employer on first job	Total number reporting 1/	Percent employed on second job by -						
		All types of employers	Educational institution	Government	Private industry	Independent consultant	Foundation	Other
All fields:								
Educational institution ..	602	100.0	68.9	12.3	16.3	0.3	2.2	--
Government	83	100.0	48.2	43.4	6.0	--	2.4	--
Private industry	160	100.0	38.1	10.6	51.3	--	--	--
Foundation	19	100.0	57.9	10.5	21.1	--	10.5	--
Chemistry:								
Educational institution ..	286	100.0	63.6	7.0	27.3	.4	1.4	0.3
Government	27	100.0	51.9	33.3	14.8	--	--	--
Private industry	131	100.0	35.1	11.5	53.4	--	--	--
Foundation	8	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
Physics:								
Educational institution ..	109	100.0	77.1	9.2	11.0	--	2.7	--
Government	4	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
Private industry	19	100.0	47.4	5.2	47.4	--	--	--
Foundation	4	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
Biology:								
Educational institution ..	207	100.0	72.0	21.2	3.4	.5	2.9	--
Government	52	100.0	46.2	48.1	1.9	--	3.8	--
Private industry	10	100.0	60.0	10.0	30.0	--	--	--
Foundation	7	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)

1/ Excludes 151 scientists not reporting type of employer on either first or second job, and 56 for whom only one job was recorded.
2/ Number too small to warrant computing percentages.

Table 23.--Types of employers for whom scientists worked on third job in study compared with type of employer on fourth job

Field of highest competence and type of employer on third job	Total number reporting 1/	Percent employed on fourth job by -						
		All types of employer	Educational institution	Government	Private industry	Independent consultant	Self-employed	Foundation
All fields:								
Educational institution ..	299	100.0	70.9	8.7	18.0	0.7	--	1.7
Government	132	100.0	31.8	46.2	19.7	.8	--	1.5
Private industry	186	100.0	17.7	6.5	68.3	2.1	2.7	2.7
Foundation	11	100.0	36.4	9.1	18.1	--	--	36.4
Chemistry:								
Educational institution ..	115	100.0	61.7	6.1	28.7	--	--	3.5
Government	41	100.0	19.5	51.2	29.3	--	--	--
Private industry	147	100.0	11.6	5.5	76.2	2.0	2.7	2.0
Foundation	6	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
Physics:								
Educational institution ..	74	100.0	79.7	5.4	12.2	2.7	--	--
Government	14	100.0	57.1	21.4	14.3	7.2	--	--
Private industry	23	100.0	47.8	4.4	39.1	--	--	8.7
Foundation	1	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)
Biology:								
Educational institution ..	110	100.0	74.6	13.6	10.9	--	--	.9
Government	77	100.0	33.8	48.0	15.6	--	--	2.6
Private industry	16	100.0	31.3	18.8	37.5	6.2	6.2	--
Foundation	4	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)	(2/)

1/ Excludes scientists who held fewer than 4 jobs.
2/ Number too small to warrant computing percentages.

GEOGRAPHIC MOBILITY

The remainder of this report deals with the kind of mobility most often studied; namely, movement from one part of the country to another. The analysis covers not only scientists' migration in the course of their employment but also their movements between States and regions in connection with their education, and the net effect of these movements on the scientists' geographic distribution. In this analysis, it has been possible to supplement the information for the sample group of scientists with certain data for all Ph.D. chemists, biologists, and physicists included in the Biographical Directory of American Men of Science.

Geographic Movement as Students

The concentration of graduate education in a relatively small number of universities and the correlative tendency for students to change schools on entering graduate studies is well known. At least among science students, however, movement for graduate work seems to go far beyond the limitations imposed by the availability of satisfactory facilities for advanced study. Even those students taking their baccalaureates in States with outstanding universities often journey to other States for graduate work.

More than 60 percent of the approximately 12,000 chemists, physicists, and biologists with Ph.D. degrees included in Bulletin 1027 obtained their bachelor's and doctor's degrees in different States (table 24). There were only 5 States (California, Illinois, Maryland, New York, and Wisconsin) which retained as graduate students more than half the scientists granted bachelor's degrees within their boundaries. The States which lost the majority of their newly created bachelors of science included such centers of education as Massachusetts, Minnesota, Pennsylvania, Iowa, and Michigan. The proportion of students going to other States for graduate study was highest, however, for the parts of the country with limited facilities for graduate work. Twenty-four States, 20 of them in either the South or the Mountain-Plains regions, saw at least four-fifths of the scientists granted B.S.'s by their institutions leave for advanced study elsewhere.

In most cases, the students who changed schools between their baccalaureate and their doctorate moved to an entirely different section of the country for graduate work. More than half the 12,000 scientists surveyed obtained their bachelor's and doctor's degrees in different regions. As in the case of interstate movements, the proportion who transferred across regional lines was highest among those students who did their undergraduate work in sections of the country without extensive facilities for advanced study in the sciences. Less than 30 percent of the men with baccalaureates from

Table 24.--Percent of scientists who received Ph.D.'s in same State as bachelor's degree, and percent currently employed in State of bachelor's degree 1/

State of bachelor's degree	Number of scientists reporting	Percent who received doctor's degree in State of bachelor's degree 2/	Percent currently employed in State of bachelor's degree 2/
United States	3/ 12,198	38.6	23.0
Alabama	57	—	19.3
Arizona	28	—	21.4
Arkansas	76	1.3	13.2
California	685	66.6	53.6
Colorado	154	18.8	18.2
Connecticut	257	48.3	13.2
Delaware	7	—	—
Florida	75	29.3	22.7
Georgia	120	4.2	20.0
Idaho	58	—	6.9
Illinois	980	53.4	21.8
Indiana	506	28.1	15.8
Iowa	400	43.5	11.3
Kansas	312	19.2	11.2
Kentucky	103	1.0	11.7
Louisiana	61	11.5	31.2
Maine	105	1.0	7.6
Maryland	229	57.6	20.1
Massachusetts	777	43.9	20.5
Michigan	506	42.9	21.2
Minnesota	405	45.7	16.5
Mississippi	74	—	18.9
Missouri	268	27.2	12.7
Montana	90	—	8.9
Nebraska	213	22.1	10.3
Nevada	4	—	(4/)
New Hampshire	139	—	7.9
New Jersey	171	45.6	26.3
New Mexico	18	—	(4/)
New York	1,165	58.5	38.2
North Carolina	159	40.9	22.6
North Dakota	50	2.0	4.0
Ohio	930	42.9	22.9
Oklahoma	92	4.4	17.4
Oregon	154	8.4	15.6
Pennsylvania	855	40.9	32.5
Rhode Island	124	32.3	5.7
South Carolina	102	—	17.7
South Dakota	96	—	3.1
Tennessee	104	15.4	16.4
Texas	248	33.9	33.1
Utah	175	1.1	25.7
Vermont	46	2.2	8.7
Virginia	190	34.7	17.4
Washington	212	36.8	16.5
West Virginia	99	13.1	23.2
Wisconsin	426	60.1	18.1
Wyoming	18	—	(4/)
District of Columbia	75	24.0	21.3

1/ Based on chemists, physicists, and biologists with Ph.D. degree included in Bulletin No. 1027, U. S. Department of Labor.

2/ The percentages in columns 2 and 3 in each case were based on the number of scientists who received a bachelor's degree in each State. Those currently employed in each State did not necessarily receive a doctorate in that State.

3/ Excludes 542 scientists who received bachelor's degrees or equivalent in foreign countries and 457 who did not report State of bachelor's degree.

4/ Number too small to warrant computing percentages.

southern schools received their doctorates in the South, and the corresponding figure for graduates of colleges in the Mountain-Plains States was still lower (table 25). However, three-fourths of the men who earned bachelor's degrees in the North Central States obtained their doctorates in that region.

Even those States attracting the largest number of graduate students from other parts of the country lost young scientists to educational institutions outside their borders. New York institutions attracted more scientists with baccalaureates earned elsewhere than did those of any other State, according to figures for the small sample of 1,122 biologists, chemists, and physicists with Ph.D. degrees. Men came from as far away as Texas and California to do graduate work in New York, but more than one-third of the New York college graduates went elsewhere for their doctorates (table E, p. 60). Illinois was next to New York in the number of scientists who earned their doctorates in that State though they had obtained their bachelor's degrees elsewhere. Nevertheless, close to half of the men in the sample who were awarded bachelor's degrees from Illinois colleges received their doctor's degrees in other parts of the country.

Table 25.--Percent of scientists receiving Ph.D. in same region as bachelor's degree, by region 1/

Region of bachelor's degree	Number of scientists reporting	Percent receiving Ph.D. in region of bachelor's degree
United States	2/ 12,072	55.8
New England	1,417	48.3
Middle Atlantic ...	2,468	68.1
South	1,553	28.7
North Central	4,123	74.0
Mountain-Plains ...	1,477	19.0
Pacific	1,034	57.7

1/ The data for all Ph.D. chemists, biologists, and physicists is based on Bulletin No. 1027, U. S. Department of Labor.
2/ Excludes 668 scientists who received baccalaureates or doctorates in foreign countries and 457 who did not report State of bachelor's degree.

It seems reasonable to suppose that the desire to see the world played some part in the exodus of these young men for graduate study. Only a minority of the students who left the State where they had earned their baccalaureates received their doctorates in nearby States. Of the 26 who left Illinois, only 10 obtained their doctorates from universities in contiguous States. Of the 27 who left New York, only 6 earned their degrees in adjacent States. Conversely, only a third of the students who earned doctorates in Illinois after taking bachelor's degrees elsewhere had received these first degrees in nearby States. College graduates from Massachusetts, Rhode Island, Pennsylvania, New Jersey, and Connecticut, formed only about a fourth of the men in the sample who had earned doctor's but not bachelor's degrees in New York (table E, p. 60).

Migration as Employees

A relatively high degree of geographic movement is characteristic of professional personnel in general. The 1940 Census showed, for example, that one out of every four professional and semiprofessional men, compared to only one out of seven employed men in the country, had changed his State of residence between 1935 and 1940. The data on the number of States in which the men in the sample group for this study had been employed suggests that Ph.D. scientists are even more mobile than the average professional man. 27/ More than 80 percent of these scientists had moved across State lines at least once in the course of the jobs studied, and more than 40 percent had worked in three or more States (table 26).

27/ Exactly comparable data are not available for either professional personnel or the population as a whole. However, in a study of manual workers of a New England city it was found that 76 percent of those for whom histories had been taken had never been employed outside of the State where they were currently working. See The Structure of Labor Markets, by Lloyd G. Reynolds. New York, Harper & Brothers, 1951. p. 37.

Table 26.—Number of States in which scientists worked on jobs included in study

Field of highest competence and number of jobs	Total number reporting	Percent of scientists				
		Total	Who worked in designated number of States on jobs included in the study			
			One	Two	Three	Four
All fields	1,122	100.0	17.6	39.3	31.1	12.0
1 job	56	100.0	100.0	—	—	—
2 jobs	197	100.0	32.0	68.0	—	—
3 jobs	255	100.0	14.5	45.9	39.6	—
4 jobs	614	100.0	6.7	30.9	40.4	22.0
Chemistry	616	100.0	21.3	41.6	28.2	8.9
1 job	42	100.0	100.0	—	—	—
2 jobs	122	100.0	33.6	66.4	—	—
3 jobs	151	100.0	14.6	44.4	41.0	—
4 jobs	301	100.0	8.6	35.9	37.2	18.3
Physics	166	100.0	10.2	38.6	34.3	16.9
1 job	3	(1/)	(1/)	—	—	—
2 jobs	26	100.0	23.1	76.9	—	—
3 jobs	29	100.0	6.9	48.3	44.8	—
4 jobs	108	100.0	5.6	27.8	40.7	25.9
Biology	340	100.0	14.4	35.6	34.7	15.3
1 job	11	(1/)	(1/)	—	—	—
2 jobs	49	100.0	32.7	67.3	—	—
3 jobs	75	100.0	17.3	48.0	34.7	—
4 jobs	205	100.0	4.4	25.4	44.9	25.3

1/ Number too small to warrant computing percentages.

There are several reasons for this high geographic mobility. The labor market for scientists is national rather than local, and scientists' positions are usually secured through university and professional contacts rather than through friends, relatives, or local employment services. It may be also that people who leave their home communities to attend schools in other parts of the country have less psychological resistance to further movement in connection with their employment than people who receive all their schooling in their home towns. It is also true that the professional advancement of educators is in some degree dependent on their willingness to transfer between universities. In the present study, the chemists, who worked in private industry, in the majority of cases, were somewhat less mobile than the other scientists, who were most often employed in educational institutions.

Although figures are not available on the relative mobility of scientists in different age groups, the study suggests that the younger men had a greater tendency toward geographic mobility than the older men. It will be recalled that the median age of the men for whom only two jobs were recorded was 37 years, compared with 40 years for those who had held at least four positions. More than two-thirds of the scientists who had held only two jobs migrated into a different State when they entered their second position. The proportion of scientists migrating each time they changed jobs declined as the number of jobs increased. Only 40 percent of the scientists for whom three jobs were recorded worked in a different State on each of these positions. Only 22 percent of the group who had had four jobs had worked in four different States (table 26).

At all age levels, however, these scientists had a much higher rate of geographic mobility than the general population. Furthermore, an examination of the schedules indicated that most of these movements across State lines represented movements of at least several hundred miles. The high geographic mobility of the scientist suggests that the location of research or development projects in areas away from the greater centers of population, where most scientists live and work, need not be a barrier to the recruitment of qualified scientists, particularly Ph.D.'s. Apparently, for a scientist, the nature of the job and the salary it offers will usually outweigh the advantages or disadvantages of its location.

Comparison of State of Employment with State of Education

Most scientists begin their careers in States where they have received at least part of their education. Two-thirds of those in the small sample began their first professional careers in the State where they had been awarded either their baccalaureate or doctorate (table 27). The men generally migrated at least once in the course of their careers, and fewer than a third (30 percent) were working in the State of either their bachelor's or doctor's degree at the time of the survey.

Table 27.--Comparison of State of first professional job and current employment with State of bachelor's and doctor's degrees

Field of highest competence	Number of scientists reporting	Percent of scientists employed in--	
		Same State as that of either bachelor's or doctor's degree	Different State from that of either bachelor's or doctor's degree
	First professional job		
All fields	1/ 1,026	67.4	32.6
Chemistry	569	66.4	33.6
Physics	150	66.7	33.3
Biology	307	69.4	30.6
	Current employment (1948)		
All fields	2/ 1,004	30.5	69.5
Chemistry	539	29.4	70.6
Physics	150	33.8	66.2
Biology	315	30.7	69.3

1/ Excludes 26 scientists who did not report State of bachelor's degree, 25 who did not report State of Ph.D., 17 who reported neither, and 28 who did not report State of first job.

2/ Excludes 23 scientists who did not report State of bachelor's degree, 23 who did not report State of Ph.D., 16 who reported neither, and 56 for whom only one job was recorded, which was coded as the first job.

The proportion of scientists currently employed in the State in which they received their bachelor's degree was only 23 percent, for all Ph.D. biologists, chemists, and physicists included in Bulletin No. 1027. California, which had retained more than half the scientists granted bachelor's degrees by its colleges, was the leading State in this respect. Four other States (Louisiana, New York, Pennsylvania, and Texas), currently employed more than 30 percent of the men who had earned bachelor's degrees in the given State. At the low end of the scale were 15 States which had retained less than 15 percent of their bachelors of science. Most of these States were in the Mountain-Plains region or in New England (table 24).

The fact that a scientist takes his doctorate in the same State as his baccalaureate is not evidence that he will continue to live and work there. For example, three-fifths of the men who were graduated from colleges in Wisconsin obtained doctorates in that State, but fewer than a fifth who received bachelor's degrees in that State were currently employed there. On the other hand, some of the States which witnessed a great exodus of students for graduate study later regained them. Less than 5 percent of the scientists who received their bachelor's degrees from Georgia colleges took their doctorates in that State, but a fifth were currently employed there.

State and Regional Gains and Losses

The movement of scientists across State boundaries, for either graduate training or employment is by no means all in one direction. In each State the gains and losses offset each other in some measure. Hence, it is necessary to align the States in terms of net loss and net gains in personnel, if an answer is to be provided to the much-discussed question. Are professionally trained men being drained off from certain sections of the country?

In order to answer this question, an analysis was made of the number of scientists who received bachelor's degrees in the different regions with the number who received doctor's degrees (for the entire 12,000 scientists). This comparison showed pronounced gains for two sections of the country--the Middle Atlantic and the North Central States-- and sharp losses for the South and the Mountain-Plains regions (table 28). Quite a different picture was disclosed when the number of bachelor's degrees granted in each region was compared with the number of scientists currently employed there. More scientists were employed in the South than had received bachelor's degrees from Southern schools. Fewer scientists were employed in North Central States than had received bachelor's degrees from North Central colleges.

Regional comparisons obscure differences among States. On the basis of losses and gains between the numbers of scientists educated and currently employed within their boundaries, the 48 States can be divided

Table 28.--Number of scientists granted bachelor's or doctor's degrees or currently employed in each region 1/

Region	Number granted bachelor's degrees	Number granted Ph.D. degrees	Number currently employed
New England	1,448	1,431	947
Middle Atlantic	2,502	3,599	5,063
South	1,560	632	1,854
North Central	4,153	5,328	3,083
Mountain-Plains	1,484	477	816
Pacific	1,051	1,085	1,350

1/ Based on chemists, physicists, and biologists with Ph.D. degree included in Bulletin No. 1027, U. S. Department of Labor.

into four groups (table 29). The first category includes those States where the number of scientists employed was greater than the number who had been awarded doctorates, and the latter figure in turn exceeded the number who had received their baccalaureates in the given State. The Middle Atlantic States, except Delaware and Pennsylvania, fall within this category (Group I), as do California, Connecticut, and North Carolina.

Table 29.--Number of scientists granted a bachelor's or doctor's degree or currently employed in each State (1948) 1/

State	Number granted bachelor's degree	Number granted Ph.D.	Number currently employed	State	Number granted bachelor's degree	Number granted Ph.D.	Number currently employed
Group I				Group III			
				Massachusetts	777	882	495
				Illinois	980	1,673	895
Connecticut......	257	430	262	Wisconsin	426	857	287
New York	1,165	1,841	1,854	Minnesota	405	471	229
New Jersey	171	306	898	Iowa	400	667	162
Maryland	229	594	466				
District of Columbia	75	145	359	Group IV			
North Carolina ..	159	210	182	Maine	105	3	56
California	685	922	1,050	New Hampshire.	139	--	47
				Vermont	46	1	36
Group II				Rhode Island..	124	115	51
				Ohio	930	783	702
				Indiana	506	373	340
Pennsylvania	855	713	1,032	Michigan	506	504	468
Delaware	7	--	454	Missouri	268	197	224
Virginia	190	132	197	North Dakota..	50	2	28
West Virginia ...	99	21	103	South Dakota..	96	1	25
Georgia	120	8	129	Nebraska	213	109	67
Florida	75	27	153	Kansas	312	89	111
Tennessee	104	45	209	South Carolina	102	1	58
Alabama	57	1	93	Kentucky	103	3	90
Louisiana	61	40	128	Mississippi ..	74	--	48
Oklahoma	92	11	147	Arkansas	76	3	50
Texas	248	130	267	Montana	90	--	42
New Mexico	18	--	59	Idaho	58	--	29
Arizona	28	5	38	Wyoming	18	--	17
Nevada	4	--	9	Colorado	154	70	89
				Utah	175	4	78
				Washington ...	212	131	189
				Oregon	154	32	111

1/ Based on chemists, physicists, and biologists with Ph.D. degree included in Bulletin No. 1027, U. S. Department of Labor.

In Group II, the number of scientists currently employed also exceeded the number granted baccalaureates. In these States, however, the number awarded Ph.D.'s was smaller than the number awarded B.S.'s. Most of the States in this category are in the South--Virginia, West Virginia, Georgia, Tennessee, Alabama, Florida, Louisiana, Oklahoma, and Texas. This group also includes a few of the Mountain-Plains States--Arizona, Nevada, and New Mexico; and two Middle Atlantic States--Pennsylvania, and Delaware. The Southern States in this category granted bachelor's degrees to 1,046 of these scientists and doctor's degrees to 415, a decrease of 60 percent. However, 1,426 scientists were employed in these Southern States, an increase of 36 percent over the number receiving bachelor's degrees there.

The category with the fewest States was Group III. In the five States in this group, more scientists were awarded Ph.D.'s than baccalaureates, but the number of scientists currently employed was smaller than the number granted bachelor's degrees. Four of these States--(Illinois, Iowa, Minnesota, and Wisconsin) are in the Middle West, and for three of the four there was a sharp drop between the number of scientists educated and the number currently employed. Over twelve hundred (1,231) of the scientists were granted their bachelor's degrees in Minnesota, Iowa, or Wisconsin, and close to two thousand (1,995) earned their doctorates in these States, but only 678 were employed there in 1948. The fifth State in the group, Massachusetts, showed a similar loss between the number of scientists educated and the number employed.

In the fourth and largest category of States, the number of scientists granted bachelor's degrees exceeded both the number currently employed and the number granted doctorates. Most of the Mountain-Plains and New England States come within this category, as do the North Pacific States, a few Mid-Western States, and a small group of Southern States.

Few Southern States, however, fall in Group IV. As was pointed out previously, the South as a whole, actually experienced an increase in the number of scientists granted bachelor's degrees as compared with the numbers currently employed. This makes it clear that the tendency for the graduates of Southern colleges to go to Northern schools for graduate work need not be a cause of concern in the South. Not all the native sons return, but recruits from other sections of the country more than make up the loss.

APPENDIX

The list of specialties used in coding the scientists jobs and subjects of study included more than 60 specific and/or general fields. The analysis indicated, however, that some of these fields were not applicable. The following are the fields in which at least some the scientists had worked in the jobs covered by the study, or had majored in for either a bachelor's or a doctor's degree. The specific fields of specialization are listed under the general fields of which they are a part.

- Chemistry
  - General
  - Inorganic
  - Organic
  - Physical
  - Analytical
  - Biochemistry
- Metallurgy
- Physics
- Electronics
- Biology
  - General
  - Bacteriology
  - Botany
  - Entomology
  - Zoology
- Agriculture
- Medicine
  - Opthalmology
  - Public health
  - Radiology
- Fields related to medicine
  - Nutrition and foods
  - Anatomy
  - Pathology
  - Physiology
  - Pharmacy
  - Pharmacology
  - Veterinary medicine
- Engineering
  - Civil
  - Chemical
  - Aeronautical
  - Electrical
  - Mechanical
  - Ordnance
  - Power plant
- Earth sciences
  - Geology
  - Geophysics
  - Meteorology
- Mathematics
- Astronomy
- General science
- Military applications of science
  - Logistics
  - Intelligence
  - Special operations
- Nonscientific fields
  - Architecture
  - Business administration
  - Liberal arts
  - Manpower resources and planning
  - Other non-scientific fields

Table A.—Specific fields of specialization in which scientists currently employed in chemistry, physics, and biology, worked on all their jobs included in the study

Fields of specialization for studied jobs	Chemistry						
	All branches	General	In-organic	Organic	Phys-ical	Biochem-istry	Analyt-ical
Chemistry:							
General	29.0	69.6	20.0	17.0	18.4	13.0	24.5
Inorganic	4.6	3.0	64.0	1.6	2.4	.4	2.9
Organic	28.9	8.2	5.3	74.0	2.1	3.5	2.0
Physical	15.0	5.0	—	1.3	65.9	—	1.0
Biochemistry	9.7	1.7	—	1.1	—	69.7	—
Analytical	6.1	5.0	5.3	1.8	2.4	2.2	59.8
Physics	.9	.8	—	—	3.0	1.3	—
Biology:							
General	.3	.5	—	.2	—	.4	1.0
Bacteriology	.6	—	—	.3	—	3.5	1.0
Botany	.5	.5	—	—	.3	3.1	—
Entomology	—	—	—	—	—	—	—
Zoology	.1	.3	—	—	—	—	—
Medicine and related fields:							
Nutrition and foods.	—	—	—	—	—	—	—
Anatomy	—	—	—	—	—	—	—
Physiology	.1	—	—	—	.3	.4	—
Pathology	.1	.2	—	—	—	—	—
Pharmacology	.1	.2	—	—	—	—	—
Pharmacy	—	—	—	—	—	—	—
Public health	—	—	—	—	—	—	—
Ophthalmology	—	—	—	—	—	—	—
Engineering:							
Chemical	.9	—	—	.7	2.4	—	2.9
Civil	.1	—	—	.2	.3	—	—
Electrical	.1	—	2.7	—	—	—	—
Mechanical	—	—	—	—	—	—	—
Ordnance	.1	.3	—	—	—	—	—
Earth sciences:							
Geophysics	—	—	—	—	—	—	—
Geology	—	—	—	—	—	—	—
Other scientific fields:							
Agriculture	.3	—	—	.2	—	1.7	1.0
Mathematics	.5	1.3	—	.2	1.1	—	—
Metallurgy	.1	.2	—	—	.3	—	—
Electronics	—	—	—	—	—	—	—
General science	1.5	2.8	2.7	1.2	.8	—	2.9
Nonscientific fields..	.4	.4	—	.2	.3	.8	1.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total number of jobs..	1,806	400	74	633	368	230	101

Table A.—Specific fields of specialization in which scientists currently employed in chemistry, physics, and biology, worked on all their jobs included in the study—Con.

Fields of specialization for studied jobs	Chemistry						
	All branches	General	In-organic	Organic	Phys-ical	Biochem-istry	Analyt-ical
Chemistry:							
General	1.0	.6	—	1.9	.6	.7	—
Inorganic	.2	—	—	—	—	—	—
Organic	.4	—	—	—	—	—	—
Physical	2.4	—	—	—	—	—	—
Biochemistry	.4	.4	.4	1.9	—	—	—
Analytical	.2	.3	.4	—	.6	—	—
Physics	84.8	.3	1.2	—	—	—	—
Biology:							
General	.6	21.0	58.5	12.0	7.8	5.9	11.5
Bacteriology	—	12.1	2.4	69.8	.3	2.0	.8
Botany	—	30.3	8.5	4.4	84.6	2.0	2.3
Entomology	—	13.7	4.4	.6	.3	79.5	3.9
Zoology	.6	14.6	14.5	3.8	.6	5.9	73.1
Medicine and related fields:							
Nutrition and foods.	—	.1	.4	—	—	—	—
Anatomy	—	.1	—	.6	—	—	—
Physiology	—	.4	.4	—	—	.7	1.5
Pathology	—	—	—	—	—	—	—
Pharmacology	—	—	—	—	—	—	—
Pharmacy	—	.1	—	—	—	.7	—
Public health	—	.4	—	2.5	—	—	—
Ophthalmology	—	.1	.4	—	—	—	—
Engineering:							
Chemical	—	—	—	—	—	—	—
Civil	—	—	—	—	—	—	—
Electrical	1.4	—	—	—	—	—	—
Mechanical	.2	—	—	—	—	—	—
Ordnance	.6	—	—	—	—	—	—
Earth sciences:							
Geophysics	.4	—	—	—	—	—	—
Geology	—	.1	—	—	.3	—	—
Other scientific fields:							
Agriculture	—	2.1	1.6	2.5	3.4	1.3	—
Mathematics	1.0	.1	—	—	.3	—	—
Metallurgy	—	—	—	—	—	—	—
Electronics	2.0	—	—	—	—	—	—
General science	2.4	2.3	4.9	—	.6	1.3	5.4
Nonscientific fields..	1.4	.9	2.0	—	.6	—	1.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total number of jobs..	499	1,009	247	158	322	152	130

Table B.--Comparison of major subjects for doctor's and bachelor's degrees

Major subject for Ph.D.	Total number reporting	Number of scientists with bachelor's degree in -- Chemistry	Physics	Biology	Medicine and related fields	Engineering	Earth sciences	Agriculture	Mathematics	General science	Business administration	Liberal arts	Architecture
All fields	1/1,060	514	114	239	13	54	2	57	25	22	1	18	1
Chemistry	569	486	5	6	7	2/38	1	4	7	9	1	5	--
Physics	140	5	108	--	--	8	--	1	14	3	--	1	--
Biology	309	16	--	223	1	1	1	44	2	8	--	12	1
Medicine and related fields.	17	2	--	7	5	--	--	3	--	--	--	--	--
Engineering ...	6	--	--	--	--	6	--	--	--	--	--	--	--
Earth sciences.	4	2	--	--	--	--	--	1	--	1	--	--	--
Agriculture ...	10	3	--	3	--	--	--	4	--	--	--	--	--
Mathematics ...	3	--	1	--	--	--	--	--	2	--	--	--	--
Metallurgy	1	--	--	--	--	1	--	--	--	--	--	--	--
General science	1	--	--	--	--	--	--	--	--	1	--	--	--

1/ Excludes 20 scientists who did not report major subject for Ph.D., 33 who did not report major subject for bachelor's degree, and 9 who reported neither.

2/ Thirty-six of the 38 bachelor's degrees in engineering were in chemical engineering.

Table C.-- Major subject for Ph.D., by specific field of highest competence

Major subject for Ph.D. degree	Chemistry: All branches	Chemistry: General	Chemistry: In-organic	Chemistry: Organic	Chemistry: Phys-ical	Chemistry: Bio-chem-istry	Chemistry: Analyt-ical	Physics	Biology: All branches	Biology: General	Biology: Bacte-riol-ogy	Biology: Botany	Biology: Ento-mol-ogy	Biology: Zool-ogy
Chemistry	95.9	100.0	97.5	97.6	98.2	82.0	95.1	7.4	1.5	1.5	7.4	--	--	--
General	30.3	56.0	50.0	21.1	42.7	11.8	34.2	2.3	.6	--	3.7	--	--	--
Inorganic	3.2	4.0	35.0	.4	--	--	7.3	--	--	--	--	--	--	--
Organic	32.9	12.0	5.0	70.7	.6	7.5	7.3	--	--	--	--	--	--	--
Physical	16.9	8.0	7.5	3.1	50.6	3.0	4.9	5.1	--	--	--	--	--	--
Biochemistry ..	8.7	12.0	--	2.3	1.2	59.7	2.4	--	.9	1.5	3.7	--	--	--
Analytical	3.9	8.0	--	--	3.1	--	39.0	--	--	--	--	--	--	--
Physics	.3	--	--	--	1.2	--	--	88.4	.6	2.9	--	--	--	--
Biology..........	1.1	--	--	.4	.6	6.0	--	.6	92.3	88.3	90.8	90.3	98.1	97.9
General	.2	--	--	.4	--	--	--	--	11.6	33.3	5.6	4.4	--	16.7
Bacteriology ..	.2	--	--	--	--	1.5	--	--	11.9	4.3	64.8	--	1.9	2.1
Botany	.5	--	--	--	--	4.5	--	--	33.2	18.8	5.6	85.0	--	--
Entomology	--	--	--	--	--	--	--	--	16.3	2.9	--	--	94.3	6.2
Zoology	.2	--	--	--	.6	--	--	.6	19.3	29.0	14.8	.9	1.9	72.9
Medicine and related fields.	1.5	--	--	.8	--	9.0	2.5	--	2.3	5.8	--	3.5	--	--
Engineering	.3	--	--	.8	--	--	--	1.8	--	--	--	--	--	--
Earth sciences ..	.2	--	--	--	--	1.5	--	--	.9	1.5	--	.9	--	2.1
Agriculture	.5	--	--	.4	--	1.5	2.4	--	2.1	--	1.8	4.4	1.9	--
Other sciences ..	.2	--	2.5	--	--	--	--	1.8	.3	--	--	.9	--	--
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total number reporting	1/ 593	25	40	256	164	67	41	163	337	69	54	113	53	48

1/ Excludes 23 chemists, 3 physicists, and 3 biologists not reporting major subject for Ph.D. degree.

Table D.--Function on first job by current function, of scientists having 3 or 4 jobs in study

Function on first job	Current function: All functions	College teaching	Research	Technical administration	Administration	Other
Routine professional work	8.5	8.2	9.7	9.5	8.2	3.0
College teaching assistance ...	32.8	39.9	29.4	27.0	18.4	36.4
College teaching	19.9	21.4	16.4	22.2	32.6	9.1
Other teaching	7.1	10.6	5.1	3.7	4.1	9.1
Research	24.8	14.5	32.8	29.7	32.6	27.3
Development	2.4	2.4	1.7	2.1	—	7.6
Design	.2	—	.8	—	—	—
Technical administration	1.6	.3	1.7	3.2	4.1	1.5
Administration	.2	.3	—	.5	—	—
Consulting	—	—	—	—	—	—
Estimating and cost analysis ..	.1	.3	—	—	—	—
Sales, technical sales, and services	.4	.3	.8	—	—	—
Editing and writing	.2	.6	—	—	—	—
Technical writing	.2	—	.4	.5	—	—
Extension work	.2	.3	.4	—	—	—
Wild life management	.5	.3	—	.5	—	3.0
Other	.9	.6	.8	1.1	—	3.0
Total	100.0	100.0	100.0	100.0	100.0	100.0
Total number reporting	1/ 873	331	238	189	49	66

1/ Excludes 243 scientists for whom only 1 or 2 jobs were recorded, and 6 who did not report function on first job.

Table E.—State of Ph.D., by State of bachelor's degree for scientists receiving Ph.D. and bachelor's degrees in different States

State of bachelor's degree	Number receiving Ph.D. in same State as bachelor's degree	Number receiving Ph.D. in different State from bachelor's degree	State of Ph.D. for scientists receiving bachelor's and doctor's degrees in different States																											
			California	Colorado	Connecticut	District of Columbia	Illinois	Indiana	Iowa	Kansas	Louisiana	Maryland	Massachusetts	Michigan	Minnesota	Missouri	Nebraska	New Jersey	New York	North Carolina	Ohio	Oklahoma	Pennsylvania	Rhode Island	Tennessee	Texas	Virginia	Washington	Wisconsin	Foreign country
Alabama	—	5	-	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Arizona	—	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Arkansas	—	10	-	1	-	-	1	-	-	-	2	2	1	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-
California	35	19	-	-	-	-	2	-	2	-	-	-	1	1	4	1	-	-	3	-	1	-	2	1	-	-	-	-	-	1
Colorado	—	10	1	-	-	1	1	-	2	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
Connecticut	10	11	2	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	1	1
Delaware	—	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
District of Columbia	3	5	-	-	-	-	2	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Florida	1	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Georgia	—	10	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	4	1	-	-	1	-	-	1	-	-	1	-
Idaho	—	4	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1	-
Illinois	33	26	1	-	-	-	-	1	4	-	-	-	2	-	2	1	-	2	3	-	2	-	3	-	-	-	-	1	4	-
Indiana	9	25	1	-	1	-	5	-	-	-	-	2	-	-	1	-	-	1	3	1	3	-	2	2	-	-	-	-	3	-
Iowa	13	21	2	-	1	-	7	1	-	-	-	-	-	-	1	-	1	1	4	-	-	-	-	-	-	-	-	-	3	-
Kansas	6	24	3	-	1	-	3	1	1	-	-	-	1	1	1	1	-	-	4	-	2	1	-	1	-	-	-	-	2	1
Kentucky	1	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Louisiana	—	3	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Maine	—	11	-	-	1	-	-	-	-	-	-	1	3	-	-	-	-	-	4	-	1	-	1	-	-	-	-	-	-	-
Maryland	19	8	-	-	-	1	1	-	1	-	-	-	-	1	-	-	-	-	-	1	1	-	1	-	-	-	-	-	1	-
Massachusetts ..	24	19	1	-	2	-	3	-	-	-	-	3	-	-	-	-	-	2	6	-	-	-	-	-	-	1	-	-	1	-
Michigan	22	30	-	-	-	-	7	4	3	-	-	2	2	-	-	-	-	-	3	-	2	-	5	1	-	-	-	-	1	-
Minnesota	9	20	2	-	1	-	1	1	3	-	-	2	5	-	-	-	1	-	2	-	1	-	-	-	-	-	-	-	1	-
Mississippi	—	10	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	3	3	-	-	-	-	-	-	-	-	2	-
Missouri	9	25	-	1	-	1	5	1	4	1	-	3	-	-	1	-	-	-	3	-	-	-	2	-	-	-	-	-	3	-
Montana	—	9	1	-	-	-	2	-	1	-	-	1	-	-	1	-	-	-	1	-	-	-	1	-	-	-	-	-	1	-
Nebraska	2	12	1	-	-	1	1	1	1	1	-	-	-	2	2	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-
New Hampshire ..	—	16	2	-	-	-	1	1	1	-	-	1	1	1	-	-	-	-	5	-	1	-	-	-	-	1	-	-	1	-
New Jersey	7	10	1	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	2	-
New Mexico	—	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
New York	48	27	3	-	1	1	6	1	2	-	-	3	1	1	-	1	-	1	-	-	-	-	3	-	-	-	-	-	2	1
North Carolina..	3	11	-	-	2	-	3	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	1	-	1	-	-	-	-	-
North Dakota ...	—	5	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Ohio	40	54	3	-	1	-	8	4	1	-	-	6	4	2	2	-	1	2	8	-	-	-	4	1	-	-	-	-	6	1
Oklahoma	—	7	-	-	-	1	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Oregon	1	10	1	-	2	-	1	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	1	-
Pennsylvania ...	29	45	4	-	1	1	8	2	-	1	-	1	6	1	-	-	-	2	12	1	5	-	-	-	-	-	-	-	-	-
Rhode Island ...	1	8	-	-	-	-	2	-	-	-	-	1	-	-	-	-	-	1	1	1	1	-	1	-	-	-	-	-	-	-
South Carolina..	1	18	1	-	-	1	1	-	-	-	-	3	1	1	-	-	-	2	1	2	2	-	-	-	-	-	2	1	-	-
South Dakota ...	—	10	-	-	-	-	3	-	-	-	-	-	-	-	2	-	-	-	1	-	1	-	-	-	-	-	-	-	3	-
Tennessee	1	8	-	-	-	-	-	-	1	-	-	1	1	1	-	-	-	-	-	-	-	-	-	1	-	-	1	-	2	-
Texas	7	9	1	1	-	-	1	-	-	-	-	1	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	2	-
Utah	—	17	4	-	1	-	2	-	2	1	1	-	-	-	1	-	-	-	1	1	-	-	1	-	-	-	-	-	2	-
Vermont	—	4	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Virginia	3	11	-	-	1	-	1	-	-	-	-	4	-	-	-	-	-	1	2	1	1	-	-	-	-	-	-	-	-	-
Washington	4	13	5	1	-	-	-	-	-	-	-	-	2	-	1	-	1	-	1	-	1	-	-	1	-	-	-	-	-	-
West Virginia ..	1	12	-	-	-	-	-	1	1	-	-	2	1	1	-	-	-	1	3	2	-	-	-	-	-	-	-	-	-	-
Wisconsin	24	18	2	-	-	2	3	3	-	-	-	-	2	-	2	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-
Wyoming	—	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-

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