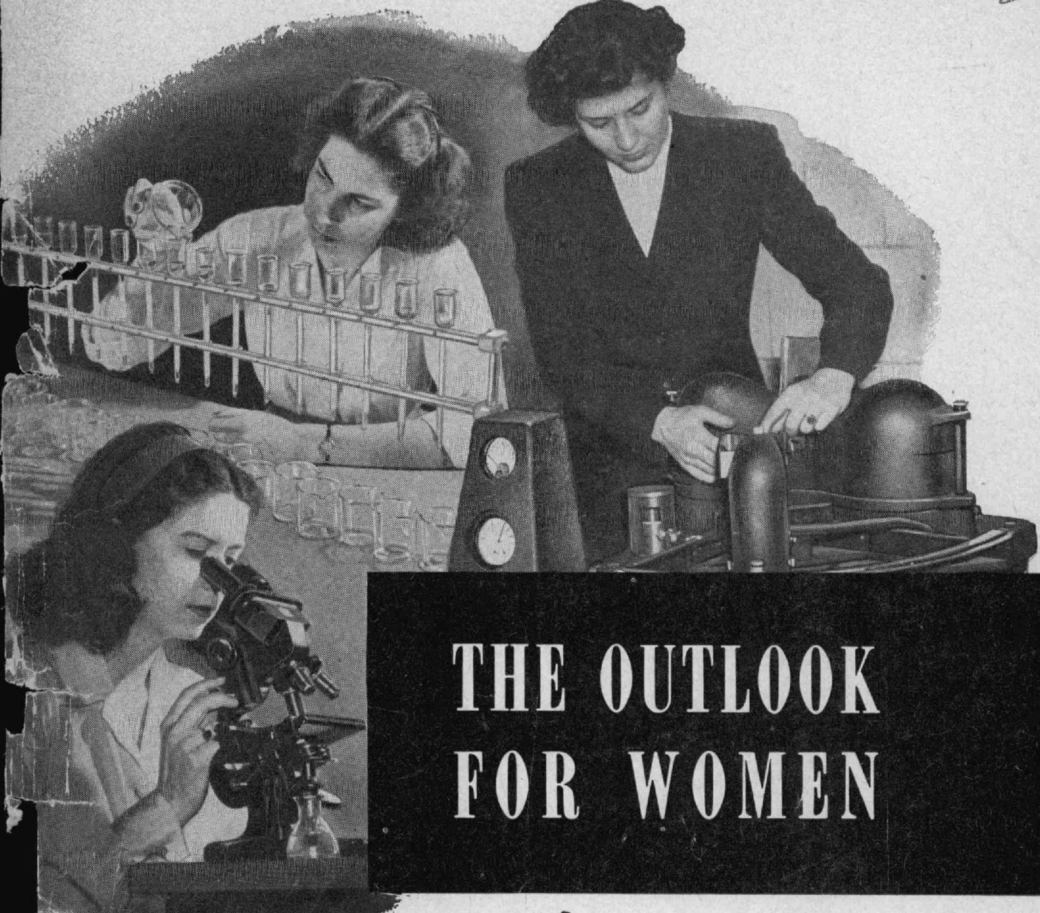

THE OUTLOOK FOR WOMEN *in* SCIENCE

Bulletin No. 223-1

U. S. DEPARTMENT OF LABOR

WOMEN'S BUREAU

UNITED STATES DEPARTMENT OF LABOR
L. B. SCHWELLENBACH, SECRETARY
WOMEN'S BUREAU
FRIEDA S. MILLER, DIRECTOR

The Outlook for Women in Science

Bulletin of the Women's Bureau No. 223–1

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THE OUTLOOK FOR WOMEN IN SCIENCE

No. 223–1 *The Outlook for Women in Science*

No. 223–2 *The Outlook for Women in Chemistry*

No. 223–3 *The Outlook for Women in the Biological Sciences*

No. 223–4 *The Outlook for Women in Mathematics and Statistics*

No. 223–5 *The Outlook for Women in Architecture and Engineering*

No. 223–6 *The Outlook for Women in Physics and Astronomy*

No. 223–7 *The Outlook for Women in Geology, Geography, and Meteorology*

No. 223–8 *The Outlook for Women in Occupations Related to Science*

Note on Pagination.—Throughout the series, page numbers show both the volume number and the page number in that volume. For example, page 24 in volume 3 is shown as 3–24; in volume 6, as 6–24.

LETTER OF TRANSMITTAL

United States Department of Labor,
Womens Bureau,
Washington, December 22, 1947.

Sir: I have the honor of transmitting this introduction to a series of bulletins on the outlook for women in science. The extraordinary demand for women with scientific training during World War II and the resulting questions which came to the Women's Bureau prompted us to undertake this study. The paucity of published information on women in science and the encouragement of the scientists and educators who were consulted in the course of this study confirmed the need for the information here assembled and synthesized. The study was planned and directed by Marguerite Wykoff Zapoleon and completed with the assistance of Elsie Katcher Goodman and Mary H. Brilla of the Employment Opportunities Section of the Bureau's Research Division. Other members of the Bureau staff who helped to broaden the coverage of this study through interviews in the field were regional representatives Margaret Kay Anderson, Martha J. Ziegler, Rebecca G. Smaltz, and another member of the research staff, Jennie Mohr. Corinne LaBarre, Research Assistant, of the Western Personnel Institute, Pasadena, Calif., furnished the information obtained from western colleges.

The part of the study here transmitted was written by Marguerite Wykoff Zapoleon with the assistance of Mildred Dougherty and Elsie Katcher Goodman.

Respectfully submitted.

Frieda S. Miller, *Director.*

Hon. L. B. Schwellenbach,
Secretary of Labor.

FOREWORD

Much has been written about science and scientists, but little has been told about the work women trained in science have done and can do in the future.

Although these women are few in number when compared to men in science or to women in such occupations as teaching and nursing, their contribution to the national welfare, so strikingly demonstrated in World War II, goes forward daily in the laboratories, classrooms, offices, and plants in which they work.

The every-day story of where these women work, of what kind of work they are doing, and of what other young women who join their ranks in the future may do has been the subject of this report on the outlook for women in science. Unlike the usual monograph which describes an occupation in detail at a particular point in time, this study, like the Women's Bureau series on occupations in the medical and health services which preceded it, is concerned primarily with changes and trends.

Although more than 800 books, articles, or pamphlets were culled for background information, the principal raw material for the entire study of which this bulletin is a part came from such primary sources as scientific organizations, employers and trainers of women scientists, and men and women scientists themselves. Principal sources were as follows:

Scientific organizations: The National Research Council supplied useful directories of scientific laboratories and organizations. Helpful criticism and direction to other authorities were obtained from its Office of Scientific Personnel. Sixty separate organizations of scientists supplied information on their women members, by interview or correspondence.

Federal agencies: Unpublished information on personnel in scientific fields was supplied by:

The United States Bureau of Labor Statistics,
The National Roster of Scientific and Specialized Personnel,
The United States Office of Education,
The United States Civil Service Commission, and
The United States Public Health Service.

In addition, 52 separate bureaus, offices, or other operating units of the Federal Government known to employ scientists were solicited for information regarding the number of women employed on jobs requiring scientific training and the type of work they were doing. Detailed statistics over a period of years were available from some agencies, while only fragmentary data were obtained from others. The women's military services likewise supplied information on the wartime use of women trained in science in the WAC, WAVES, and the Marine Corps.

Private industry: One hundred industrial firms were visited in 1945 and 1946 to obtain information, usually by interview with the director of research or the personnel director, on the women employed by any part of the organization in any capacity requiring scientific training of college level. Prewar, wartime, and postwar statistics were obtained where available, as well as suggestions and comments. In many instances, some of the women in scientific work were interviewed on the job. The firms visited included:

Seventy-eight firms listed in the National Research Council's 1946 directory of 2,443 firms having research laboratories. The firms visited are listed in the directory as employing 24,816 persons as scientific or technical personnel in their laboratories. This number represented 28 percent of the total personnel of this type estimated as employed in all the laboratories listed. In addition to this numerical coverage, an attempt was made to include among the 78 firms visited small as well as large firms, plants in all parts of the United States, and a variety of industries. However, the intricate industrial organization, inter-relationships, and variety of research revealed in the directory, added to the fact that some firms did not report personnel statistics and none reported women separately, made the selection of a true sample complicated beyond its value for this purpose. The firms visited were chosen rather as a clue to industrial firms most likely to be engaged in the type of work in which women trained in science are used. In all firms, information was requested for the entire organization rather than for the research laboratory only.

Eighteen commercial laboratories which offer testing services to industry and individuals and which employed women were also visited. Seven others contacted did not employ women. These 25 laboratories represented 10 percent of the 244 commercial testing laboratories listed in the National Bureau of Standards' 1942 Directory of Commercial Testing and College Research Laboratories. Since personnel is not reported in the Directory, there is no clue to the coverage of workers.

Three large additional industrial firms which employed women in laboratory work but were not listed as having research laboratories were visited, as was one biological supply house.

Research institutions: Eight research institutions or centers, some of them identified with a particular college or university, also supplied information on women members of the scientific staff.

Colleges and universities: Statistical information on the number of women graduated with degrees in science, mathematics, and engineering over a period of years from 1939–40 to 1946 was obtained from 30 colleges and universities and from 9 engineering schools. Again an attempt was made to obtain wide geographical coverage and to cover different types of institutions, such as women's colleges, State universities, and small liberal arts colleges. The information available from these sources, too, varied. Placement bureaus and heads of science departments as well as deans of women at these institutions and at 6 other colleges contributed reports on the demand for women trained in the sciences. The Western Personnel Institute made possible the inclusion of data which it collected for the Bureau from its affiliated colleges and universities in the far West. Since no recent data were available on the number of women teaching science in the colleges, a count was made in 1947 of the women identifiable by name who were listed on science faculties in the catalogs of 330 institutions of higher learning which were then available in the United States Office of Education Library. These institutions were selected because they are believed by the United States Office of Education to be representative in their enrollments of the 1,749 institutions of higher education in the United States and, therefore, are likely to have faculties equally representative.

Other sources: In addition, 97 individuals not included in the afore-mentioned sources, most of them women scientists, contributed information, suggestions, or helpful criticisms of the preliminary manuscripts circulated before revision for publication.

While every effort has been made to obtain wide coverage, there remain some dark corners still unexplored because of the range and variety of these fields and the difficulty of obtaining information from widely scattered sources. Perhaps this beginning will result in further additions to our so-little knowledge.

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Courtesy U. S. Department of Agriculture

Figure 1.—A chemist studying the stability of insecticidal emulsions.

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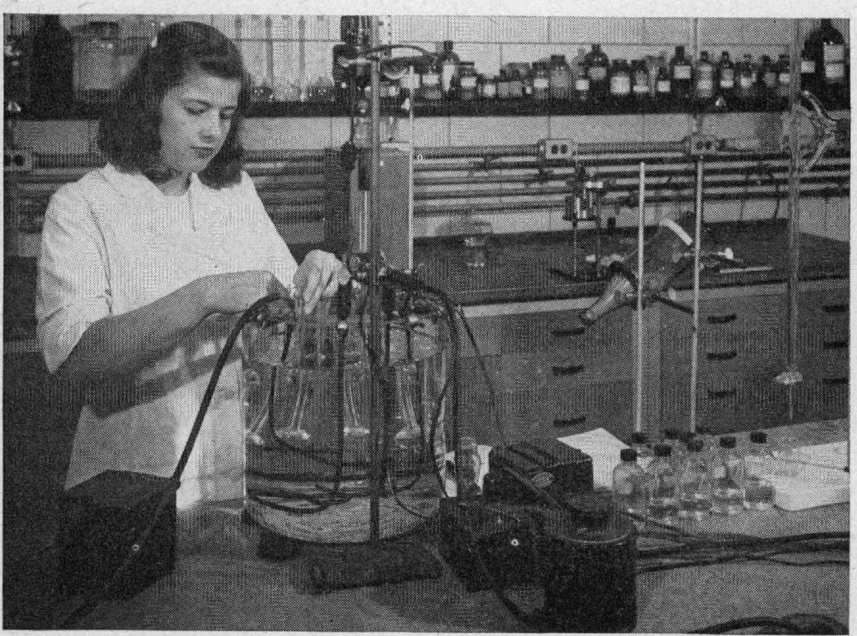

Courtesy Mellon Institute

Figure 2.—Developing relative viscosity measurements on a project in physiochemical research.

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Courtesy U. S. Atomic Energy Commission

Figure 3.—Technicians trained in biology or biochemistry observing behavior of uni-celled animals in radioactive phosphorus solution at one of the laboratories of the U. S. Atomic Energy Commission.

THE OUTLOOK FOR WOMEN IN SCIENCE

EMPLOYMENT IN THE SCIENCES

The role of women in the sciences has been a minor one. A year or more after the close of World War II, with its extraordinary demand for scientifically trained women, less than 3 percent of the non-medical personnel in the sciences in the United States were women. Yet, the contributions of this small group have many times been declared "essential," and exceptional women scientists have won international renown.

The importance of the sciences to individual and national welfare and the rarity of creative scientific talent suggest the questions: Is our Nation finding and developing all its potentially great scientists? Is it developing and utilizing without waste the services of other scientifically trained persons to whom the creative group supplies the inspiration and leadership?

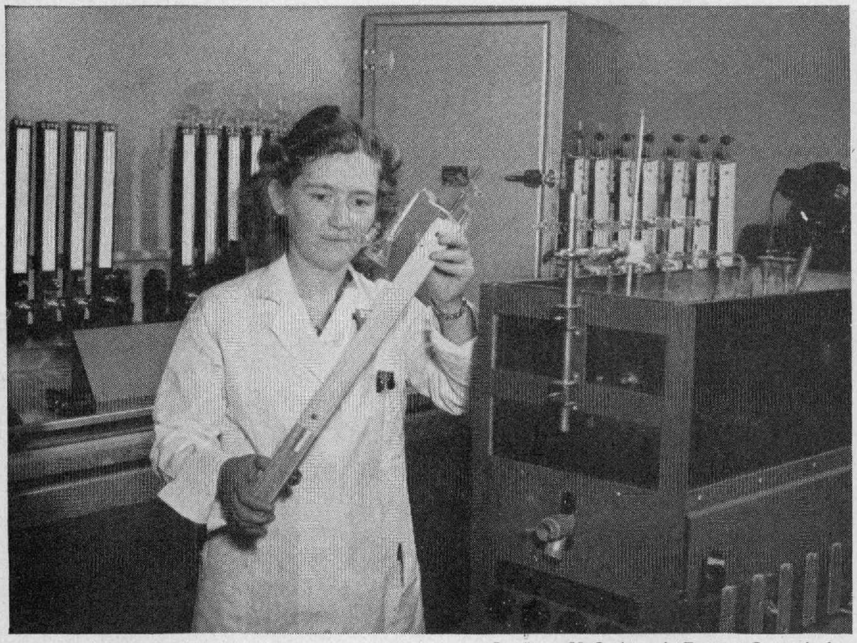
Both the legislative and the executive branches of Government have recognized the vital nature of these questions, as the proposed National Science Foundation and the recent report of the chairman of the President's Scientific Research Board indicate (*49*) (*45*). The Women's Bureau believes that, although women will probably never equal the number of men in scientific fields, they can and will play an increasingly greater role, quantitatively and qualitatively, in the sciences. For this, certain changes in actions, both on the part of women themselves and on the part of those who employ and train scientists, are necessary. The Bureau presents this factual report as a basis for its belief and as its initial contribution both to the increasing number of women who want to train for scientific work and to those who are concerned with the present and potential use of a relatively unmined source of scientific talent.

The report deals primarily with the outlook for women in the physical and biological sciences and in mathematics. The applied fields of engineering and architecture have also been included. The social sciences, which require a different combination of talents and training, and the fields of medicine and dentistry (which have been the subjects of earlier reports of the Bureau) have been omitted.

The boundary in depth of this study has also been somewhat arbitrarily set. Should only those who have taken a Ph. D. or a Sc. D. in science and continue to be actively engaged in scientific work be counted as "scientists?" Should all who are actively employed in such work be included even though their academic training is more limited, for example, to a bachelor's degree with a science major? As the discussions of particular sciences in other parts of this series indicate, the lines drawn in the various scientific fields are by no means well-defined as to level. In mathematics, particularly, there are some who consider the Ph. D. essential for the classification of "mathematician," whereas others would include all those who have an undergraduate major in mathematics and are actively engaged in mathematical work or the teaching of mathematics. In physiology and astronomy the lines are clearer—those without the doctorate, who are not candidates for it, do not usually call themselves physiologists or astronomers. On the other hand, among engineers a doctor's degree is rare. In chemistry, many have the doctorate, but it is possible to become a chemist through experience with only the bachelor's degree and, in very unusual instances, even without a college degree. Where there are conflicting points of view, an attempt has been made in the separate bulletins to give statistics on both the exclusive and the more inclusive groups. Generally, however, the bachelor's degree with a major in a science, mathematics, engineering or architecture, or its equivalent has been the minimum level for this study. With a few exceptions, only incidental information is included on women with less training in science.

Even with these arbitrary boundaries drawn, the current picture of women in science is necessarily befogged by the difficulty of obtaining separate statistics on their number and their functions, and because of the intermeshing of the sciences which makes classification difficult. These inter-relationships are evident in such titles as: astrophysicist, geobotanist, biochemist, biophysicist, and chemical engineer. They are present also, though not so obviously indicated in the titles, in such occupations as those of the mineralogist, paleontologist, and oceanographer.

The story of how the sciences have at once "differentiated" and "hybridized" is a long and fascinating one that begins in ancient times (*28*). As one scientist says, "The boundaries between all sciences are arbitrary and man-made, and it is impossible to say how much one borrows from another." Any grouping, therefore, is not only arbitrary, but, to some extent, inexact. For this reason, broad categories have been used here. The difficulties of even these classifications are reflected in the variations in offerings in science in colleges and universities. One school will offer a bachelor's degree with a major in biology; another, for very similar work, will offer a degree with a major in botany or zoology but not in biology. Major work in geology may be offered in a separate geology department, or in combination with geography, or as a part of earth sciences. The bacteriology department, like that of physiology, may be located in a school of medicine, a school of agriculture, or in a school of arts and sciences where it may be distinct or included in a department of biology.



Courtesy U. S. Atomic Energy Commission

Figure 4.—A biochemist studying Warburg apparatus.

Classification is also complicated by the fact that many individuals qualify as specialists in more than one field. A scientist following a problem approached from one field may end up in the same branch reached by another who has approached the problem from a different specialty. A chemist and a physiologist, for example, may ultimately both work in biochemistry and qualify as biochemists as well as in their original fields. A physiologist, in discussing his own profession, recently wrote "* * * there are independent parallel classifications of workers according to training, according to organism or organ

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studied, and according to purpose or viewpoint * * * most * * * [physiologists] have equal rights to at least two or three professional labels—occasionally even a fourth if they earn their living by teaching courses with titles not directly reflecting their research interests" (*9*).

Employment of Women in Various Scientific Fields

The totals as well as the separate estimates of the number of men and women in the scientific fields as shown in table 1 must be interpreted with these difficulties of boundaries and classifications in mind. The source of each estimate indicates its nature and its limitations.

The relatively small role women play in the sciences is at once evident, amounting to less than 3 percent of the total. Granted that table 1 presents minimum estimates in 1947, probably less than 15,000 women were engaged in professional work in the sciences as here defined, as compared with some half a million men. If engineering which occupies two-thirds of the men in these fields is excluded, women still comprise only 7 percent of the total in all the other fields. Among scientists trained at the graduate level including engineers with Ph. D.'s, women form about 5 percent of the total, according to the Office of Scientific Personnel of the National Research Council.

The proportion women are of the total employed in certain sciences, however, is much greater than their ratio in others. (See table 1 and chart I.) In bacteriology, they form one-fourth of the total; in mathematics and in general botany and in general biology, approximately one-fifth. In geography, astronomy, physiology, general zoology, and pathology, they comprise between one-tenth and one-fifth. On the other hand, in engineering, in the agricultural plant sciences and animal husbandry, and in meteorology, they total 1 percent or less.

However, the largest scientific fields for women in terms of the actual number employed are: Chemistry, which employs 42 percent of all the women in science; mathematics, which employs 16 percent; and bacteriology, engineering, and physics, each of which employ 7 to 8 percent. (See chart II.) For men, on the other hand, engineering is overwhelmingly predominant, while chemistry ranks second. (See chart I.) Physics, architecture, and geology fall next in order. Each of these fields as well as mathematics and the agricultural plant sciences employ more men than the number of women employed in the largest scientific field for women, that of chemistry.

Table 1.—*Estimated Number and Percent Distribution of Men and Women in Principal Scientific Fields in the United States, 1946–47*

NOTE.—These estimates are derived from a variety of sources and should be interpreted with caution. (See sources of estimates below and discussion in text on difficulties of classification and variations in training levels.) The totals are for the sciences listed and do not include *all* those whose work or training includes science. Medicine is the largest of the groups omitted.

Scientific field	Number			Percent			Percent women are of total
	Total	Men	Women	Total	Men	Women	
All fields listed below	477, 890	465, 130	12, 760	100. 0	100. 0	100. 0	2. 7
Architecture [1]	15, 000	14, 700	300	3. 14	3. 16	2. 35	2. 0
Astronomy [2]	600	500	100	. 12	. 11	. 78	16. 6
Bacteriology [3]	4, 000	3, 000	1, 000	. 84	. 65	7. 84	25. 0
Biology, general [4] (exclusive of bacteriology, botany, zoology)	3, 200	2, 600	600	. 67	. 56	4. 70	18. 8
Botanical Science:							
General botany [5]	1, 100	850	250	. 23	. 18	1. 96	22. 7
Plant physiology and pathology [4]	1, 050	980	70	. 22	. 21	. 55	6. 7
Agricultural plant sciences [4] including forestry	7, 850	7, 820	30	1. 64	1. 68	. 23	. 4
Chemistry [6]	77, 000	71, 600	5, 400	16. 11	15. 39	42. 32	7. 0
Engineering [7]	317, 000	316, 050	950	66. 33	67. 95	7. 45	. 3
Geography [8]	800	660	140	. 17	. 14	1. 10	17. 5
Geology [9]	11, 000	10, 670	330	2. 30	2. 29	2. 59	3. 0
Mathematics [4] (exclusive of statistics)	10, 200	8, 150	2, 050	2. 13	1. 75	16. 07	20. 1
Meteorology [10]	2, 800	2, 770	30	. 59	. 60	. 23	1. 1
Physics [11]	18, 450	17, 550	900	3. 86	3. 77	7. 05	4. 9
Zoological Science:							
General zoology [4]	3, 900	3, 470	430	. 82	. 75	3. 37	11. 0
Physiology [4]	900	790	110	. 19	. 17	. 86	12. 2
Pathology [4]	650	590	60	. 14	. 13	. 47	9. 2
Animal husbandry [4]	2, 390	2, 380	10	. 50	. 51	. 08	. 4

[1] Estimate of registered architects in 1947 by Department of Education and Research, American Institute of Architects. This does not include landscape architects. The percentage of women is estimated at twice their 1 percent proportion in the American Institute of Architects and less than their 2.3 percent in the 1940 Census figures in which landscape architects were included.

[2] American Astronomical Society 1946 membership.

[3] Estimate based on 1947 membership of Society of American Bacteriologists, which exceeded 3,000 and which includes more experienced group.

[4] National Roster of Scientific and Specialized Personnel, Registrants, Dec. 31, 1946 (*38*). These are minimum figures, as indicated by a comparison with table 4, p. 1–20.

[5] Rounded estimate of number available in 1946 made by a committee of the Botanical Society of America (*6*). Proportion of women based on distribution of membership in the Society in 1945 and of National Roster registration.

[6] Estimate of the total obtained by adding the 9,360 Ph. D.'s in chemistry active in 1947 according to the National Research Council's Office of Scientific Personnel to the 18,720 master's and 48,672 bachelor's in chemistry, estimated by applying a ratio of 2 master's to 1 Ph. D. and 5.2 bachelor's to 1 Ph. D. (These are the ratios among scientists in industrial research laboratories, according to the same source.) The percentage of the total who are women is estimated at 7 percent, slightly higher than the 6 percent ratio found in 1946 in a 10 percent sample count of the 48,000 members of the American Chemical Society in which the ratio of women is probably lower than among nonmembers.

[7] Estimate of total for March 1946 as given in Engineers Joint Council survey report. Proportion of women based on 1940 Census distribution (*34*).

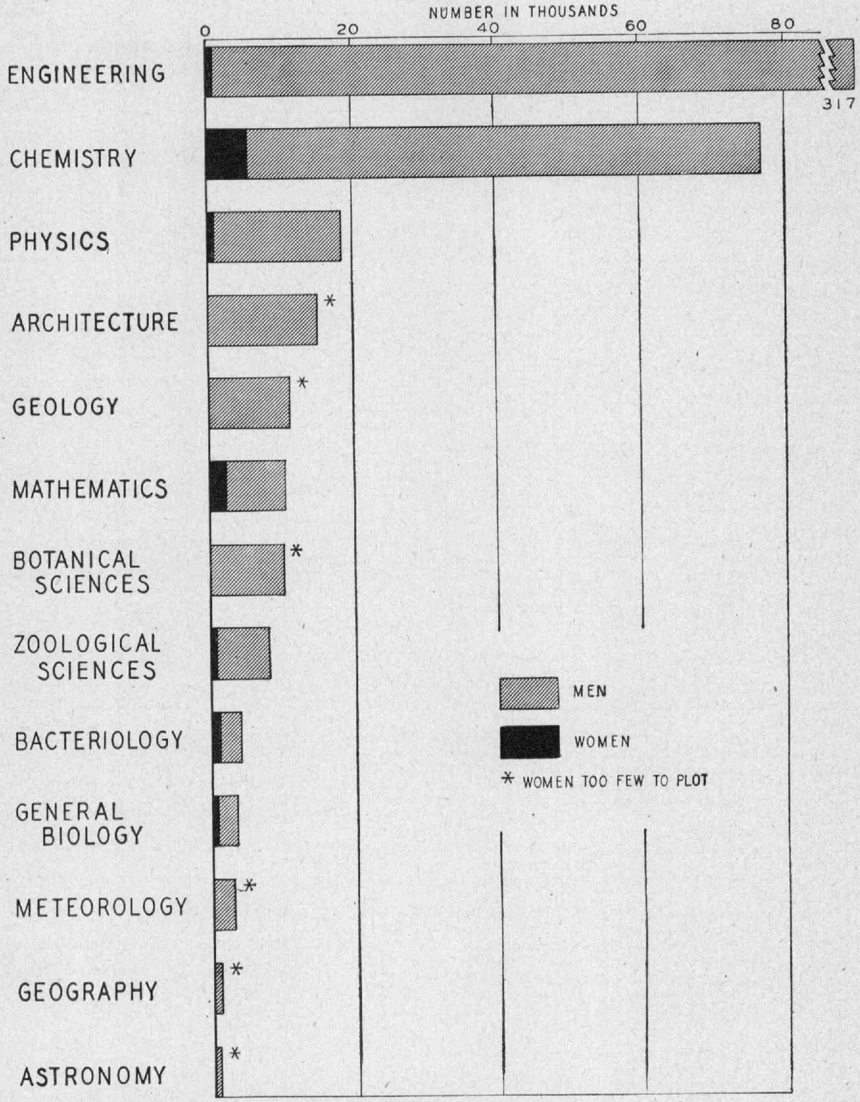
[8] 1946 Census of Professional Geographers by Division of Geology and Geography of National Research Council.

[9] Estimate of the Geological Society of America, 1946.

[10] American Meteorological Association membership, 1947.

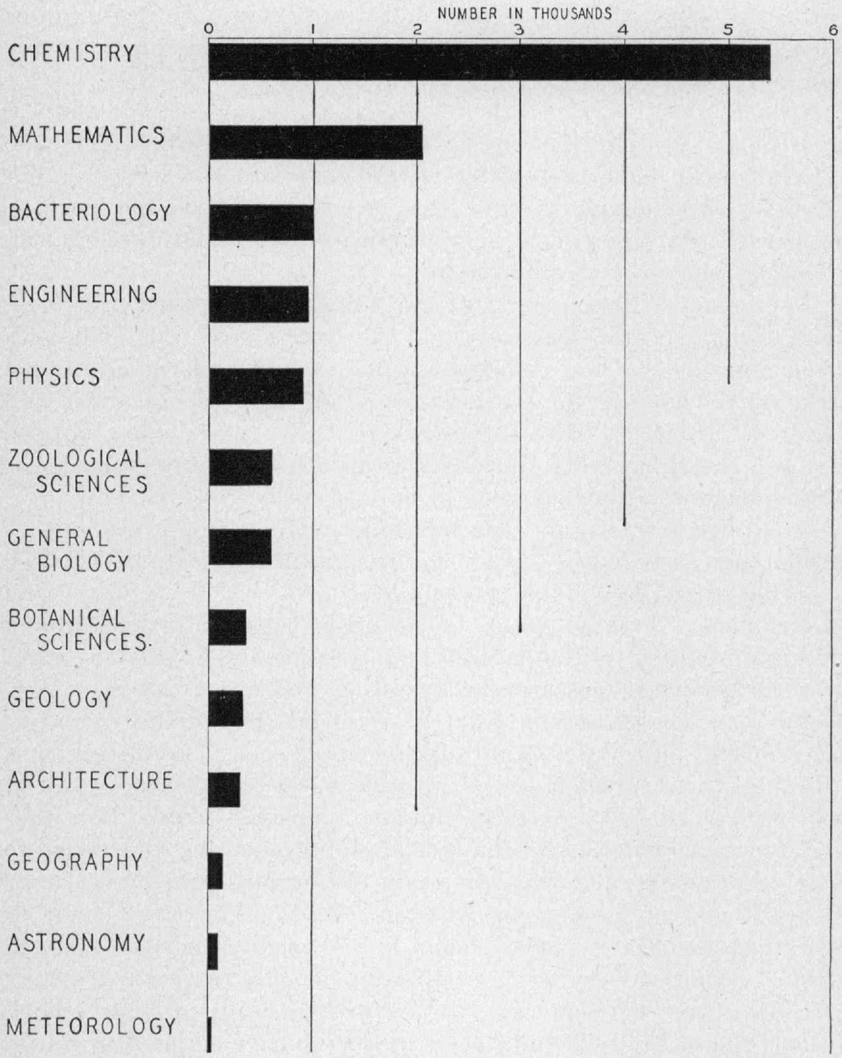
[11] Estimate of the total obtained by adding the 2,250 Ph. D.'s in physics active in 1947 according to the National Research Council's Office of Scientific Personnel to the 4,500 master's and 11,700 bachelor's in physics, estimated by applying a ratio of 2 master's to 1 Ph. D. and 5.2 bachelor's to 1 Ph. D. (These are the ratios among scientists in industrial research laboratories, according to the same source.)

Chart I.—Men and Women in Principal Scientific Fields in the United States, 1946–47.



SOURCES: SEE SOURCES FOR TABLE I. PRINCIPALLY PROFESSIONAL ORGANIZATIONS AND THE NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

Chart II.—Women in Principal Scientific Fields in the United States, 1946-47.



SOURCES: SEE SOURCES FOR TABLE I, PRINCIPALLY PROFESSIONAL ORGANIZATIONS AND THE NATIONAL ROSTER OF SCIENTIFIC AND SPECIALIZED PERSONNEL

The Type of Work Women in Science Do

The variety of occupations in which women college graduates who have majored in science are engaged is described in more detail in the separate bulletins in this series. They range from the simplest type of routine laboratory work to the most difficult type of research work, for which the doctorate usually represents only a beginning. They may include the teaching of high school science or a professorship in a large university.

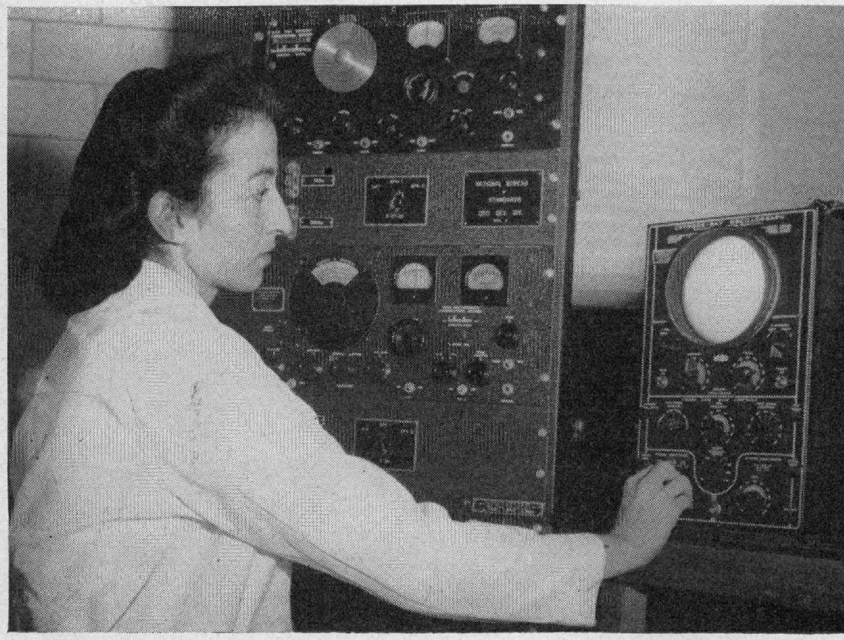
Although the boundaries here, too, are not clear cut, and there is interchange and overlapping between the groups, certain principal types of work have been differentiated. In scientific research, for example, three major groups may be distinguished—the pure or basic scientists, those engaged in applied research and development, and those who do background research (*44*).

Pioneering at the outskirts of our knowledge are the pure or research scientists who seek to extend the frontiers of what is known, often regardless of the immediate, practical value of the additional territory. They are for the most part employed in university and research institution laboratories where basic rather than applied research is emphasized. Marie Curie was one of the few women who have won international renown in pure scientific research (*8*).

In applied research and development, a larger group of scientists develop new uses and new products through the application of known scientific principles. They are employed primarily by industry and Government. A third group of scientists engaged in background research provide essential data for both the pure and applied scientists by their systematic observation, recording, and organization of facts useful as a foundation or point of reference for further research. Government, industry, and universities employ scientists of this type.

Besides these three classes of research scientists, another group of persons trained in the sciences work in industrial plants, hospitals, and other operating establishments applying scientific knowledge to existing processes, materials, or products to insure their adequacy or to test their composition or qualities. Among these are plant or operating engineers, control chemists, and medical laboratory technicians. Another very large group are primarily teachers of science in colleges and universities. Others are teaching in high school, although most high-school teachers of science have majored in education rather than in science. Another group is engaged in such related occupations as patent work, technical library work, or in scientific writing, editing, or illustrating.

Obviously, the boundaries between all these types of scientific endeavor are set by the inclination, ability, training, and opportunity



Courtesy U. S. Bureau of Standards

Figure 5.—A physicist engaged in developmental research on the design and internal characteristics of radio and electronic tubes.

of the individual rather than by an arbitrary limitation of function. The control chemist or the plant engineer may experiment in the development of a new product or a new process. Similarly, an applied research chemist may hit upon a new chemical element or a new scientific principle. But the opportunity and the equipment available for pioneer exploration favor the pure scientist, who usually has a doctor's degree. The doctorate is also necessary for advancement in college teaching. In control work, on the other hand, the bachelor's degree is more usual.

These different types of scientific work are found in each of the sciences, although in some sciences the number working in one type may be proportionately larger than that in another. Among those engaged in astronomy, for example, pure research, background research, and teaching predominate; in chemistry, engineering, and geology, on the other hand, applied research, actual processing and control work, and related occupations engage a higher proportion of the total personnel. These differences in each field and the varying participation of women in them are brought out in the other bulletins in this series.

Below the general level of the college graduate who has specialized in science are the scientific aids in Government and the nongraduate laboratory assistants or technicians in industry who assist scientists in their work. Such workers, mentioned only incidentally in this study, have been steadily growing in number with the growth of specialization. Before the war, this work was usually performed by a man or woman who had taken some science in college, or in high

Courtesy U. S. Department of Agriculture

Figure 6.—A scientific aid determining the breaking strength of a cotton sample.

school, or who, lacking any scientific training, had by accident, interest, or personal relationship obtained an unskilled job in a laboratory and had learned to perform more skilled procedures on the job. During periods of oversupply, persons with more training sometimes took such jobs in order to obtain a foothold in a laboratory. Others, with partial training, took them in order to finance the completion of their college work at night. Some were graduates of private technical schools.

The engineering-aid training programs and the engineering-drafting programs for women sponsored during the war by a number of industrial corporations as well as the special training programs of the Federal Government added some thousands of specially trained women aids of this type at a critical time.

The need for some women trained at this level for subprofessional technical jobs will continue, but its volume will be relatively small in relation to the demand for men technicians and in relation to the demand for women with more training in science. However, a committee on vocational technical training appointed by the United States Commissioner of Education in a 1944 report, suggesting that programs to produce technicians be expanded, recommended that training for such occupations be made available to women students as well as to men (*42*). In Philadelphia, in 1947, 2-year courses of this nature in industrial chemistry and in architectural drafting were being offered in the public vocational school program to women as well as to men high-school graduates. In the bulletin on architecture and engineering in this series, the work of women engineering aids and draftsmen has been described. Otherwise, only incidental mention of this semiprofessional group appears in this report.

The Work Environment in Scientific Employment

The environment in which a scientist, man or woman, works varies both with the type of work he does and also with the type of employer he has. The science professor working in a university obviously spends time in the classroom as well as in the laboratory. However, the laboratory is the setting most characteristic of the scientist, as the office is characteristic of the clerk. Some scientists spend all their working time in the laboratory; others spend a part of it in an office or a library. Some leave the laboratory incidentally to obtain samples or to observe the object of their study in its natural environment. Others may spend most of their time in "field work." Geologists and mining engineers, for example, may work at sites where there are known or are believed to be oil or mineral deposits. Certain foresters, mechanical engineers, or entomologists may spend most of their time outside the laboratory in forests, in manufacturing plants, or in insect-breeding areas, respectively. Others

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in these same fields may be in the laboratory or at desks most of the time. The mathematician is perhaps the only one whose work is primarily at a desk, where he usually has special equipment in the form of calculators, slide rules, logarithmic tables, and other reference works. On the whole, women have been relatively few in the occupations entailing field work and relatively more numerous in the desk jobs. However, they are found in every type of employment.

Courtesy U. S. Department of Agriculture

Figure 7.—An entomologist identifying a new and strange insect by comparison with known insects in the Smithsonian Institution collection.

The laboratories in which they work vary not only in size but in appearance and type of equipment, according to the subject of study. In astronomy, an observatory, usually located on a point higher than the surrounding terrain, is typical. In meteorology, the weather station is characteristic. Both have special equipment used for observation or testing or calculating. This equipment, largely mechanical, resembles that found in a physics or engineering laboratory more than it does that in a chemical laboratory. Machinery seems to dominate as compared with the solutions, powders, glassware, and noticeable odors to which a chemist becomes accustomed. In biological laboratories, one is likely to find living animals and/or plants used for study, the ever-present microscope, slides, and media for cultures.

Because of the interrelationships in science itself and because a practical problem often involves the use of a number of sciences, even a small laboratory may actually be a combination of several types of laboratories. Almost all medium-sized and large laboratories have separate units classified either according to the science primarily used or according to the type of problem or product studied.

In the United States Bureau of Standards, for example, some of the principal divisions are as follows: Chemistry, electricity, optics, and heat and power. The Bureau of Human Nutrition and Home Economics of the United States Department of Agriculture, one of the largest laboratory employers of women, includes such divisions as: Foods and nutrition, textiles and clothing, housing and household equipment.

One large industrial company in the metal-products field, in addition to its plant-control laboratories, both physical and chemical, has the following research and developmental laboratories: Metallurgy, chemistry, physics, ceramics and nonmetallics, products research, and welding research, in addition to a photography group and a library group.

A large research laboratory in a foods corporation includes the following departments: Organic chemistry, colloid chemistry, physical and inorganic chemistry, food technology, biochemistry, microbiology, analytical chemistry, chemical engineering, mechanical development, technical kitchen, manufacturers' service.

A small ceramics company has a plastic laboratory which includes chemical and physical research, an analytical chemical laboratory, a ware testing laboratory, a ceramics research laboratory, and a glass composition research laboratory.

In a sizable drug company, the scientific division includes six laboratories: Bacteriology (with separate units for control, product, and research), organic chemistry, analytical (chemical) control, pharmacy, biochemistry, and pharmacology (which includes units on pathology-hematology, bio-assay work, and research). An additional miscellaneous group works directly under the head of the division, usually on ordinary examinations, and runs the library.

A large chemical corporation, in addition to many works or control laboratories, has the following divisions in its central research laboratories: Research, physics, technical service, biological-pharmacological, mining chemicals, and chemical engineering. There are numerous subdivisions and smaller units within these departments.

A laboratory in a merchandising company which tests, evaluates, and works on the development and improvement of merchandise, has the following divisions: Chemical, textile, electrical, home economics, and mechanical and combustion.

In a large medical research institution, the department of laboratories conducts investigations in chemistry, pathology and bacteriology, and physiology. Each of these divisions is further subdivided. The pathology and bacteriology laboratory, for example, includes a special laboratory of cancer research. In addition to the department of laboratories and the department of hospitals where infectious, metabolic, and cardiovascular diseases are studied, there is a department of animal and plant pathology.

Some laboratory work, especially of the control type, may be carried on in a setting that looks very much like a college chemistry laboratory with long laboratory tables equipped with sinks, burners, test-tube racks and other equipment in frequent use. Other laboratories may look more like parts of an industrial plant with miniature ovens, machinery, or physical testing equipment. Research laboratories especially are likely to have some individual cubicles or small laboratories where the research scientist may work alone or with one or two assistants, assembling his own materials and equipment. Some equipment, either because it is extraordinarily costly or because it must be used under certain conditions (of lighting, temperature, humidity, or sound, for example), may be housed in a separate room where control can be maintained without interrupting other work. Laboratories using animals for experimentation usually house them in separate quarters handy to the laboratory.

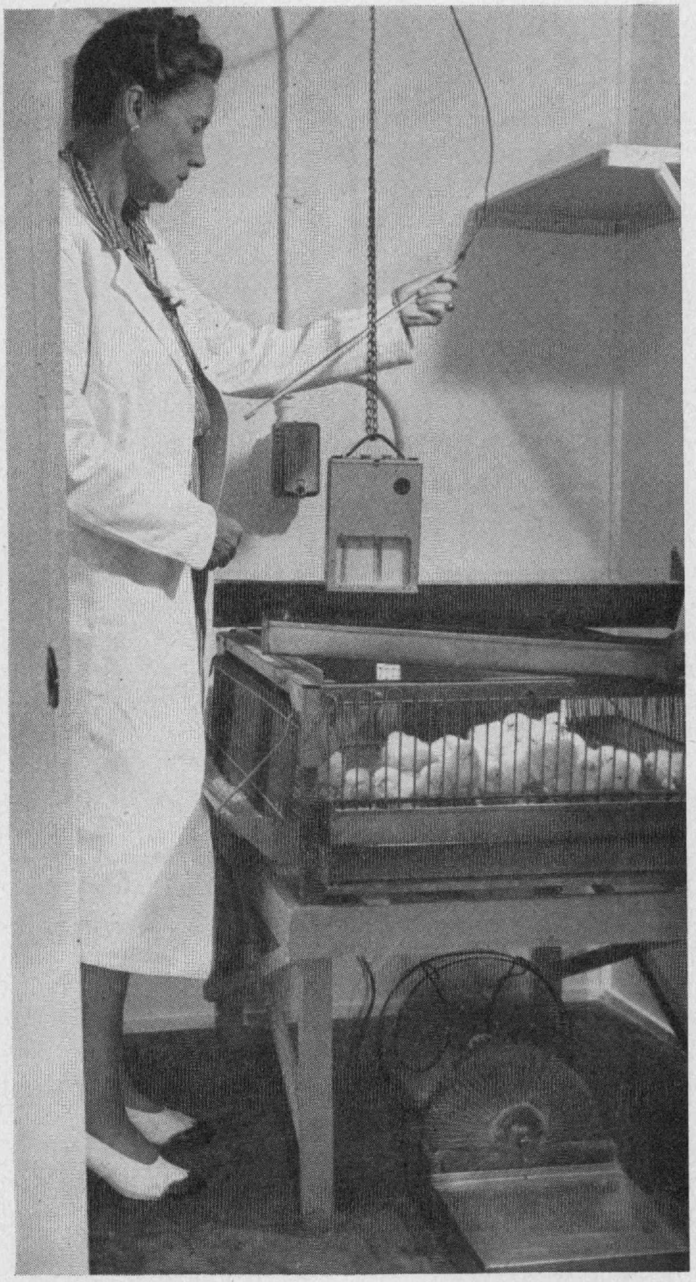
Another type of laboratory is the pilot plant which, like an experimental kitchen, is in effect a laboratory that attempts to reproduce the environment in which a product is made, processed, or used under desirable, controlled circumstances. Such a plant, of course, pioneers in operating procedures.

There are infinite variations in size as well as type. These range from a one-room control laboratory to one or more buildings devoted to laboratory work to a building especially constructed for unusual scientific equipment such as observatories for telescopes or buildings to house cyclotrons used in splitting the atom.

Types of Employers of Women in Science

There are no statistics showing the distribution of all scientific workers according to the type of laboratory or establishment in which they work. For some of the sciences, such as chemistry and engineering, comprehensive data are available from recent surveys, and such information is presented for specific fields in the other bulletins in this series. Here, only the over-all picture and the differences are emphasized.

The amount of self-employment for both men and women in the sciences included in this report is almost negligible except in archi-



Courtesy U. S. Department of Agriculture

Figure 8.—A physicist, at work on heat elimination and respiratory exchange of poultry, taking a humidity reading in a specially equipped room.

tecture. About half of all architects are self-employed (*35*), compared to chemists and engineers of whom about 3 percent are self-employed (*3*) (*11*).

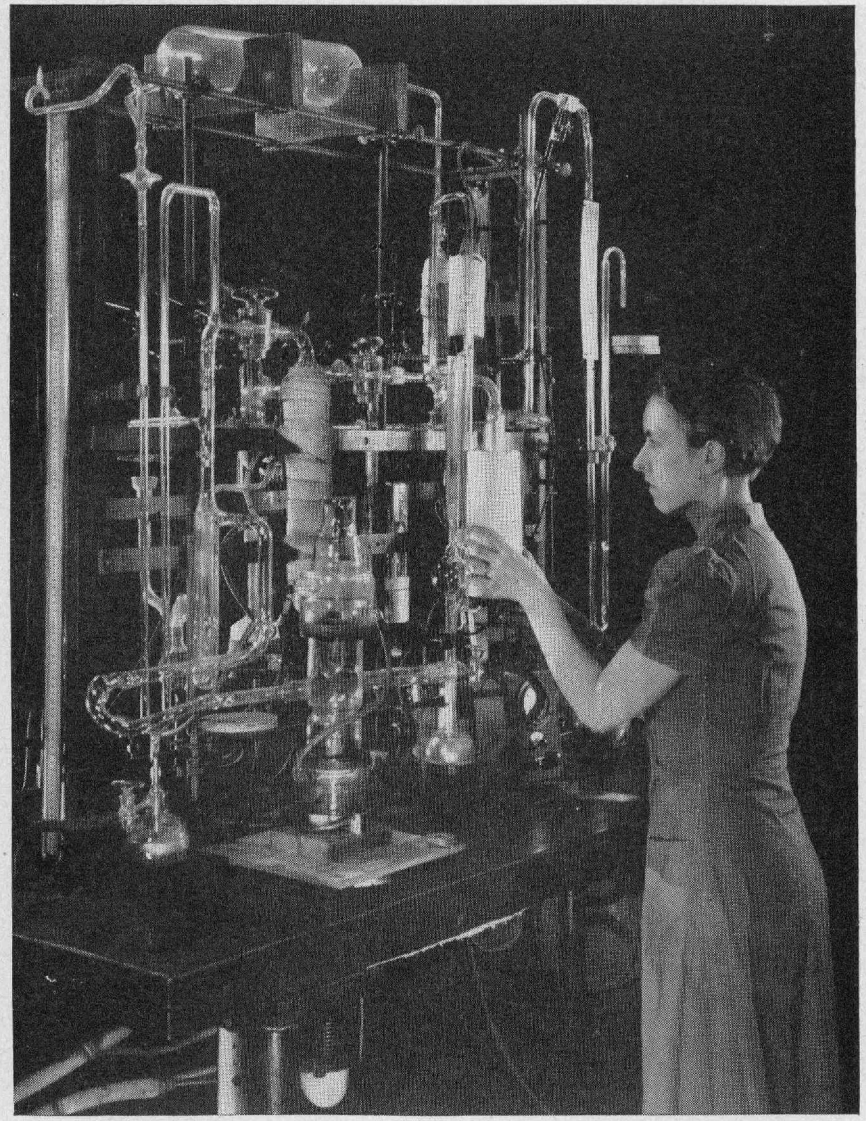
For scientifically trained persons not self-employed, wide differences in type of employer are evident when the various fields are compared. In mathematics and geography, for example, the majority of professional workers are in educational institutions, where they are primarily teachers. In engineering, chemistry, and geology, on the other hand, the majority are employed in industry. In meteorology and civil engineering, Government is the principal employer.

An examination of the available statistics on the three principal employers of scientists—industry, Government, and educational and research institutions—supplies another view of the distribution of the employment of scientific workers. Although here, too, there is the handicap of a variety of sources and classifications, and information by sex is not always available, gross comparisons are indicative.

In 1946, almost 55,000 scientific personnel and an additional 35,000 technical personnel not classified as full scientists were employed in industrial research laboratories in the United States, according to the National Research Council (21). These figures do not include some 45,000 clerical, maintenance, and administrative personnel. The technicians, being for the most part less specialized and less highly trained, were not grouped according to principal field. But more than three-fourths of the scientific personnel were reported to be divided about equally between chemists and engineers, who numbered roughly 21,000 each. Physicists, metallurgists, and biologists (including bacteriologists) ranked next. The 5,500 in other scientific professions represented a group almost as large, showing the variety of sciences represented. No figures are available on the proportion of men and women in these laboratories.

In addition, of course, there is another large group of men and women, mostly chemists with some bacteriologists and other biological scientists, employed in control or testing laboratories or in plant work. Engineers, architects, and geologists, not self-employed or engaged in research, teaching, or Government work, also swell this group employed in private industry.

In 1945–46, information was obtained by the Women's Bureau from 78 industrial firms having research laboratories which employed more than 28 percent of all persons estimated as working in such laboratories. From most of them statistics were obtained on the number of women college graduates with a major in science, engineering, or mathematics who were employed not only in the research laboratory but in the control laboratory, engineering department, library, or any



Courtesy Crane Research Laboratories

Figure 9.—Analyzing gases taken off metal in an industrial research laboratory.

other part of the organization. Eight of them employed no women of this type, although they had done so during the war or at some previous time. From two, only rough estimates were available. For the remaining 68 firms, the distribution of the college women trained in science employed by them, according to the field of scientific work in which they were engaged, is shown in table 2. The predominance of chemistry and the extensive use of women trained in a combination of sciences or in one of several optional sciences are evident. Mathematics and technical library work were the other principal occupations of this group of women employed in industry.

Of seventeen commercial testing laboratories which had employed women with a college major in science at some time, 11 were found to employ 32 women of this type in 1946. (See table 2.) Women trained in chemistry, in a combination of sciences, or in an optional science again were more numerous than those from other specified scientific fields.

Table 2.—*Women College Graduates Employed in 68 Industrial Firms With Research Laboratories and in 11 Commercial Testing Laboratories, by Type of Scientific Work, 1945–46*

Type of scientific work	Number		Percent	
	68 industrial firms with research laboratories	11 commercial laboratories	68 industrial firms with research laboratories	11 commercial laboratories
Total	2,063	32	100.0	100.0
Miscellaneous scientific work [1]	848	11	41.1	34.4
Chemistry	622	17	30.2	53.1
Mathematics	189		9.2	
Engineering	80		3.9	
Bacteriology	44	1	2.1	3.1
General biological science	39	2	1.9	6.3
Physics	38		1.8	
Botanical science	9		.4	
Zoological science	4	1	.2	3.1
Architecture	2		(2)	
Technical library work	123		6.0	
Technical illustrating	21		1.0	
Patent work	16		.8	
Technical secretarial work	16		.8	
Technical writing or editing	12		.6	

[1] Includes those engaged in laboratory or other scientific work requiring a combination of sciences, such as physics and chemistry, or those for whom the specific science was optional within a group, such as chemistry, biology, or physics.
[2] Less than 1/10 of 1 percent.

Source: Women's Bureau, 1945–46.

The total employment of scientific personnel in universities has been estimated by the President's Scientific Research Board at 50,000 in 1946–47. The proportion of women as well as the number engaged in teaching each of the separate sciences is not given in this report (*48*). But more than 2,400 women were among the more than 20,000 persons reported in December 1942 by the National Roster of Scientific and Specialized Personnel as faculty personnel in the scientific fields included in this study. The Roster report covered 90 percent of the institutions of higher education in the United States. (See table 3.) Over one-fourth of the men and women faculty members combined were in engineering; the combined biological sciences, mathematics,

Courtesy Monsanto Chemical Co.

Figure 10.—A technical illustrator putting into a drawing a health physicist's idea for a new research instrument.

and chemistry each accounted for roughly one-sixth. Women teachers were most numerous in the biological sciences and mathematics, where they also formed a higher proportion of all teachers than they did in any other field except geography, where they were one-third (*39*).

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Other statistics on women members of science faculties were obtained by the Women's Bureau in a count in 1947 of such women (identifiable by name) in catalogs of 330 institutions of higher education in the United States. These institutions are believed by the United States Office of Education to be a representative sample of all such institutions in the United States with respect to enrollments. Table 4 shows the distribution of the faculty women in science in the

Table 3.—*Women on Science Faculties in 1,573 Institutions of Higher Education in the United States, December 1942*

Scientific field	Number		Percent		Percent women are of total
	Total	Women	Total	Women	
Total in the sciences reported separately	20,031	2,422	100.0	100.0	12.1
Biological sciences (including zoology, botany, etc.)	3,557	782	17.8	32.3	22.0
Mathematics	3,483	686	17.4	28.3	19.7
Chemistry	3,464	485	17.3	20.0	14.0
Physics	2,328	178	11.6	7.3	7.6
Geography	488	157	2.4	6.5	32.2
Engineering	5,394	50	26.9	2.1	.9
Geology	657	46	3.3	1.9	7.0
Meteorology	324	28	1.6	1.2	8.6
Architecture	336	10	1.7	.4	3.0

Source: National Roster of Scientific and Specialized Personnel (*39*).

Table 4.—*Women on Science Faculties in Institutions of Higher Education in the United States, by Principal Scientific Field, 1946*

Scientific field	Women on science faculties in 330 institutions of higher education		Women on science faculties in all 1,749 institutions of higher education in the United States, if sample is representative
	Number	Percent	
Total	1,798	100.0	7,722
Chemistry	402	22.4	1,585
Mathematics [1]	304	16.9	1,415
Zoological sciences	208	11.6	778
General biology	194	10.8	1,001
Botanical sciences	112	6.2	493
Bacteriology	94	5.2	315
Physics	70	3.9	347
Geography	31	1.7	115
Geology	25	1.4	93
Engineering	16	.9	53
Astronomy	11	.6	64
Architecture and landscape architecture	6	.3	20
Meteorology	4	.2	16
Miscellaneous or unidentified science	142	7.9	590
More than 1 science	136	7.6	635
Science combined with nonscientific work	43	2.4	202

[1] Does not include count of 13 women teaching statistics, estimated total 44.

Source: Women's Bureau count of women listed on science faculties in catalogs of 330 institutions of higher learning included in an enrollment sample of the U. S. Office of Education. The sample included 22 publicly controlled complex universities and 20 privately controlled universities representing 131 institutions of these types. It included 53 public and private colleges of arts and sciences representative of 557 institutions of that type. 71 technical and professional schools and 56 public and private teachers colleges represented 287 and 201 schools, respectively. 30 public and 47 private junior colleges and 31 Negro institutions represented 468 junior colleges and 105 Negro institutions of higher education.

Courtesy Ohio State University

Figure 11.—An assistant professor in bacteriology supervises an injection made by a student, while an assistant instructor holds the rabbit.

sample institutions and the number that would be found in all, if the sample is as truly representative of faculties as it is of enrollment.

The predominance of specialization in chemistry, mathematics, and the biological sciences among women scientists in colleges and universities is again evident in table 4. A trebling in total number from 1942 to 1946 is also indicated, although the figures in tables 3 and 4 cannot be compared exactly because of differences in coverage and method. However, a sizable increase in the number of women on science faculties in 1946 as compared with 1942 is likely, in view of the enormous postwar increase in college enrollments and the employment of women to replace men faculty members who have not returned to college teaching.

On the periphery of this study, since some have majored in mathematics or science in college although most of them have not, are a large number of high-school teachers; 40,000 teachers of mathematics, some 50,000 teachers of science, and some 1,000 teachers of geography. Many of these are women.

Unlike these high-school teachers, college teachers of science not only have the bachelor's degree but a graduate degree in science as well. Many of them, in addition to teaching, are engaged in research either independently or as a member of a team on a larger research project being carried on at the institution.

In 1946, 292 educational institutions were listed by the National Research Council as offering research services to industry (*21*). Pure scientific research was also carried on principally in colleges and universities which spent 42 million dollars on research in 1940 (*45*). This was about equal to only one-sixth the research expenditures of industry and to two-thirds that of Government. During the war, the universities spent much less on research, since the Federal Government financed projects at more than 300 colleges and universities diverting available personnel to wartime research. Many additional scientists and a larger number of aids and technicians, many of them women, were hired by the colleges to work on these Federal projects which were directed by the regular faculty research group.

Table 5.—***Professional Scientific Men and Women in Federal Agencies Engaged in Research, by Scientific Field, 1947***

Scientific field	Number	Percent
Total	29, 600	100. 0
Engineering scientists	11, 600	39. 2
Agricultural scientists	7, 800	26. 3
Chemists	2, 600	8. 8
Physicists	1, 750	5. 9
Meteorologists	1, 200	4. 1
Entomologists	750	2. 5
Mathematicians	700	2. 4
Geologists	500	1. 7
Others, including bacteriologists, pathologists, physiologists, and astronomers	2, 700	9. 1

Source: The President's Scientific Research Board (*47*).

Table 6.—***Women College Graduates Employed in 50 Units of the Federal Government, by Type of Scientific Work, 1946***

Type of scientific work	Number	Percent
Total	881	100. 0
Chemistry	224	25. 4
Mathematics	134	15. 2
Engineering	78	8. 9
Physics	61	6. 9
Bacteriology	46	5. 2
Zoological science	30	3. 4
Geology	26	3. 0
Botanical science	18	2. 0
Biology, general	17	1. 9
Meteorology	15	1. 7
Architecture	5	. 6
Geography	3	. 3
Miscellaneous scientific work [1]	27	3. 1
Technical library work	111	12. 6
Technical illustrating	39	4. 4
Technical writing or editing	28	3. 2
Patent examining	19	2. 2

[1] Includes those engaged in undesignated scientific work or in work requiring a combination of 2 or more sciences.

Source: Women's Bureau, 1946.

Similar to the research work done in universities, but less closely related to teaching, is that carried on in such independent research institutions as the Rockefeller Institute for Medical Research and the Carnegie Institution of Washington. In 1940, about 13 million dollars was spent on scientific research of this type and on all other research outside industry, colleges, and Government (*45*).

Government is a large employer of men and women trained in the sciences and has been absorbing an increasing proportion of them (*45*). In such units as public-health laboratories, sanitation and highway commissions, and geological surveys, State governments employ chemists, bacteriologists, engineers, geologists, and others trained in the sciences. During the war, of course, the Federal Government not only financed the work of scientists in colleges and universities and industry but also expanded its own personnel especially in the War and Navy Departments. In 1947, 2 years after the cessation of hostilities, some 30,000 persons with professional civil service ratings as physical, biological, or agricultural scientists or engineers were employed in scientific activities in Federal agencies engaged in research, according to the President's Scientific Research Board (*48*). As shown in table 5, the largest groups were agricultural scientists and engineers working in research agencies.

Courtesy U. S. Public Health Service

Figure 12.—A public health laboratory worker searching for malaria parasites in a blood sample.

The total number of women employed in scientific work in the Federal Government is not known. But the Women's Bureau in 1946 obtained statistics from more than 50 separate bureaus and other units of the Federal Government which were reported by the United States Civil Service Commission to be principal employers of scientific workers. From some, only partial statistics were available so that the numbers given represent a minimum. However, the variety of the scientific work done by women is indicated, and it is probable that the volume of women's employment in scientific work approaches and may exceed 1,000 (table 6). The employment of women in Government scientific work appears to be more varied as to scientific field and less concentrated than it is in industry. However, chemistry and mathematics rank highest in Government as they do in industry and in educational institutions.

THE SUPPLY OF SCIENTIFIC PERSONNEL

The usual difficulties of adjusting the supply of workers in a given field to the demand for them are found in even greater degree in the sciences. The inadequacy of current information on job openings and the lack of mobility of trained personnel are handicaps in these fields as in others. Regional and local differences in demand in the sciences are noted later. The long and specialized preparation required for scientific work is an additional factor which impedes a ready adjustment of supply to demand.

Training and Supply

Training as a factor in supply becomes more important at the graduate level of preparation but must also be reckoned with at the bachelor's degree level. The scientific fields discussed in this bulletin, unlike medicine, do not have minimum requirements set by law for all those engaged in them. Among them, engineering and architecture are the only fields in which licensing is provided for in all or most States. In 1946, most architects and about one-third of the engineers were registered. For registration, graduation from an approved school or the equivalent is usually required in addition to specified experience and, often, the passing of certain examinations. In these and in some of the nonlicensed fields, there are also standards of education and job experience required for membership in professional organizations which influence, although they do not in any sense set, requirements for employment. These are described in other bulletins in this series. In chemistry, as well as in engineering and architecture, standards have been established for approved courses of training. Such standards over a period of years influence both employers and training centers, raising the usual requirements for employment and extending the customary training period.

These standards, combined with the increasing complexity of scientific knowledge, have tended toward longer education. In engineering, for example, where graduate training is not customary, the trend is toward a 5-year undergraduate course as compared with a 4-year course (*26*). In the physical and biological sciences, where graduate training is usual, the number of Ph. D.'s was increasing rapidly before the war. In 1941, 2,000 Ph. D.'s were awarded in the sciences, an 8-fold increase over the 1912 number. The increase in advanced study in the sciences during that period was twice as great as the increase in college enrollments generally (*32*).

The number of Ph. D.'s awarded in the sciences each year represents an addition to the supply of scientists qualified by their high degree of academic specialization for research and college teaching positions. In addition to the 2,000 doctorates in the sciences awarded in 1941, the major addition to the supply that year was derived from the 17,000 persons who received a bachelor's degree in one of the sciences and the 14,000 engineers who were graduated that year (*32*). Perhaps 1,000 of these graduates entered schools of medicine or dentistry or took other professional work. A small additional number, mostly women, for family, health, or other reasons, did not enter work requiring scientific training. The number of newcomers to full-time employment in the sciences and engineering in the last year before World War II was, therefore, probably in the neighborhood of, and probably less than, 30,000, including 2,000 Ph. D.'s and some 14,000 engineers. An unknown number, amounting to less than 10,000 of these, merely replaced persons who died, retired, or transferred to nonscientific work.

The supply of persons in scientific work, therefore, was increasing before the war at both the higher Ph. D. and the lower bachelor's degree levels. However, the rate of growth varied in the different fields, as discussed in other bulletins in this series.

Effect of World War II on the Supply

In addition to the acceleration of college programs, other attempts were made during World War II to increase the supply of scientific personnel to meet the tremendous additional demand, especially for engineers, physicists, chemists, and mathematicians. But the long and specialized type of training required to prepare persons fully for scientific work placed a limit on these attempts. In the military services, men and a few women, already prepared in the sciences or engineering, were given specialized training for highly specialized scientific tasks. And, under the Engineering, Science, Management War Training program financed by the Federal Government in more than 200 colleges and universities throughout the country, more than one million men and more than one-fourth million women were trained mainly as aids or assistants to engineers, chemists, or physicists (*41*). Some of the latter, also, received additional training for war tasks. But the principal increase achieved through this program, like that attained through the engineering aid and drafting programs set up by industry and Government and described in Bulletin 223–5 in this series, was at the semi- or sub-professional level. This increase, however, enabled the professional scientific personnel to spread their skills over a wider area and freed them from many of the more routine tasks that in peacetime they are called upon to perform.

While this type of conservation of the supply already trained for scientific work was taking place, however, the primary source of additional scientists was virtually cut off by the drafting of the young men who normally make up the college enrollments in the sciences and engineering. During the early part of the war, the Army Specialized Training Program and the Navy V–5 and V–12 programs enabled some of these young men to remain in college, and some of the more advanced students were deferred from military service. But, in spite of many objections, the United States ultimately drafted its potential scientists along with other young men who qualified for military service. This wartime curtailment deprived the Nation of about one-half of its normal increase in scientists and an aggregate during the war years of 90,000 bachelors of scientific subjects, plus some 5,000 Ph. D.'s, according to the President's Scientific Research Board (*48*). It also resulted in a higher proportion of women graduates among those who completed their training during this period.

In 19 scattered colleges and universities of various types which supplied statistics on the number of women obtaining degrees in science or mathematics before the war, during the war, and in 1945–46, for example, that number increased steadily from 479 bachelor's in 1939–40 to 617 bachelor's in 1945–46, a total increase of 29 percent. Master's and doctor's degrees awarded to women at these institutions also increased in the same period from 90 to 118, a 31 percent increase.

Following the end of the war, the encouragement and financial aid supplied by the GI bill resulted in the highest college enrollments in the history of the Nation, and in record enrollments in engineering (where they doubled the prewar number), in chemistry, and in physics. In geology and the biological sciences, however, the National Research Council's Office of Scientific Personnel reported that enrollments seemed to have decreased in spite of the increase in demand. In 1946, the number of bachelor's degrees awarded in science totaled 35,000. This corresponded roughly to the usual prewar number, but it was not enough to make up the wartime deficit or to meet the constantly growing peacetime demand for scientific personnel. The production of Ph. D.'s in 1946 was still a third below prewar levels, and deficits were expected to continue to 1957, since it takes "an average of 10 years of training to prepare for independent scientific research." (*48*)

In 1947, the President's Scientific Research Board predicted a quantitatively ample supply of scientists by 1957. In 1947, no oversupply

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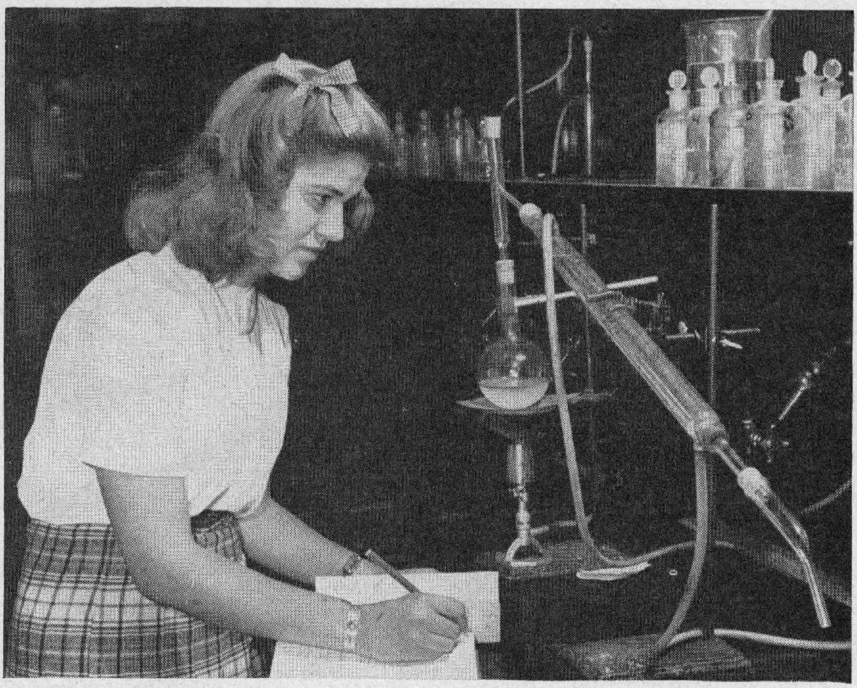


Courtesy University of Cincinnati

Figure 13.—An engineering student in the chemistry laboratory.

in any field appeared probable, but engineers were declared to be in better supply than any other major scientific group (*48*).

The Board, however, like others who have examined the situation, expressed concern over the quality of the supply of scientific personnel produced (*45*). Science classes in most colleges and universities were too large in 1947 for individual attention and encouragement. Although twice as many science and engineering students were enrolled in 1946–47 as compared with the years preceding the war, science faculties had increased only one-third and were not as highly trained. Only greater maturity and effort on the part of science students and the varied wartime experience of some of the faculty members could offset the handicaps which beset scientific education in the early postwar period.

Potential Supply

The long and specialized character of the preparation required for scientific work affects the supply of scientific workers in another way. Its costliness in terms of both time and money undoubtedly results in the loss of some talented individuals who might otherwise prepare themselves for work in this field. This is particularly true of young women because, traditionally, investment in the education of the sons of a family is made at the expense of higher education for the daughters, where a choice must be made. This fact coupled with the greater withdrawals of women for marriage and family reasons explains in part the difference between the number of college degrees awarded to men and the number awarded women. The divergence increases with the length of study required for the degree. Before the war, in the year 1939–40, according to the United States Office of Education, 41 percent of the bachelor's degrees, 38 percent of the master's degrees, and only 13 percent of the doctorates were earned by women (*40*).

The small proportion of women ordinarily earning doctorates in the sciences has been indicated in the discussions of particular sciences in other parts of this series. Marriage and the home responsibilities of women, both single and married, will continue to keep this proportion lower than that for men. But other factors reducing the proportion can be eliminated, such as the lack of encouragement and financial aid which now deters an unknown number of qualified young women from undertaking training for a scientific field. The importance of this potential supply of women scientists has been pointed out before (*16*).

Financial Aid.—Progress has already been made in the form of an increasing number of assistantships, fellowships, and scholarships available to women to assist them in financing graduate work in the sciences. However, all expenses of the training are seldom covered. College teaching fellowships or assistantships have been the usual method of encouraging talented young women to continue their study. These vary with the college that offers them but usually carry a stipend of $800 to $1,500 which the recipient earns through working half time as an instructor or as a research assistant. The remaining time is spent in study which is generally tuition-free. Memorial fellowships and others sponsored by industrial firms or other organizations are available for predoctoral research usually in a specified field. Special grants for professional work at the postdoctoral level are also offered. In 1946, at least 300 companies were financing approximately 1,800 fellowships, scholarships, or grants for scientific research, the largest number of which were in the field of chemistry (*17*). The Institute of Women's Professional Relations, in its 1947 revision of Fellowship and Other Aids for Advanced Work, has brought together information on fellowships, scholarships, assistantships, and special grants for professional or advanced work having a value of $100 or more for the academic year. Loan funds have not been included. The volume gives a brief description of all other awards for both men and women reported by 479 colleges and universities, professional schools, and other organizations.

More than 300 of the awards carefully described do not specify the subject field of study. Among those in specified subject fields, more than 600 were in science, mathematics, or engineering. Among these, the largest number were in chemistry, the second largest in engineering. Most of the biological sciences were well represented. Mathematics and bacteriology were less often specified than other subject fields. In almost all fields, there were some awards designated for women students only and others which indicated a preference for women students.

The availability of loan funds and part-time work arrangements, as well as of scholarships and assistantships, in 188 colleges offering graduate degrees, is indicated in a Directory of Colleges and Universities Offering Graduate Degrees and Some Form of Graduate Aid, compiled in 1946 by the National Roster of Scientific and Specialized Personnel (*37*). Many large industrial companies also finance in whole or in part tuition for undergraduate or graduate courses in science approved by supervisors for members of the laboratory or engineering staffs. Time off for such study up to 5 hours a week is also permitted in one such company, for example, to encourage its staff to continue their scientific education.

The American Association of University Women each year awards a number of predoctoral and postdoctoral fellowships of $1,500 each to women of the United States who wish to study in the United States or abroad as well as fellowships for women from other countries to study in the United States. These have enabled a number of women to continue research or study in science and in other fields. The John Simon Guggenheim Memorial Foundation, the National Research Council, and the National Institute of Health are among the other agencies and organizations that award fellowships directly to both men and women to pursue research or further study at the doctoral or postdoctoral level (*12*). Sigma Delta Epsilon, an organization of graduate women in science, annually awards a national research fellowship to a woman to continue research in a scientific field. In spite of the scholarships available, however, there was a great and immediate need for more predoctoral and postdoctoral fellowships in science in 1947 to enable men and women who had been diverted to other work during the war to continue their training or to catch up with new developments in their fields (*48*).

At the undergraduate level, almost every college and university has some money available for scholarships or loans. In addition, many of the local clubs affiliated with national women's organizations grant scholarships or loans to individual women. There was in 1947, however, no program for women comparable to that offered to men under the Naval Reserve Officers' Training Program which financed 4 years of college for selected male high-school graduates who agreed to enter the Navy, Marine Corps, or Naval Reserve following a period of active duty upon graduation (*32*). However, the fact that 7,000 to 8,000 men were enrolled under this program in 1947, like the existence of the Veterans' Readjustment Program, relieved the load on existing scholarship funds established for both men and women.

Although proposals have been made for a national program of undergraduate and graduate scholarships in science (*44*) (*48*), and provision for such a program was approved by the Congress in the proposed National Science Foundation, there was in 1947 no such Government-financed program under which future women scientists might be trained.

During World War II, most scholarship funds were not drawn upon heavily because of the increase in family incomes, the diversion of men and women to military action or war production, and the existence of a variety of war training programs like the Engineering, Science, and Management War Training program, the Nurse Cadet Corps program, and the engineering aid training programs sponsored by Government and industry. As the Veterans' Readjustment Program tapers off, however, additional aid at the undergraduate level will be needed, according to the President's Scientific Research Board. The Board quotes a recent study in New York State showing that only 24 percent of the students graduating in the top fourth of their high-school class fail to go on to college if their family's income is over $9,000 a year, while among a similar scholastic group from families where the income is less than $5,000, half the students do not go to college (*48*).

Encouragement in High Schools.—Specialization in scientific fields, with the exception of engineering and architecture, does not usually take place until the latter years of the undergraduate course in college and is often postponed to the postgraduate years. However, the ground work in mathematics and science is usually laid in the secondary school. It is at this stage that so many girls are diverted from establishing a foundation upon which a scientific specialization can be built. Young men in high school are often urged by their parents to take science and 3 or 4 years of mathematics, while young women are encouraged to substitute languages, history, or other optional subjects. Four years of science and 4 years of mathematics are rarely found in the background of young women high-school graduates. While it is unlikely that the number of women preferring science and mathematics to other subjects will ever equal the number of men taking those subjects, it is undoubtedly true that more qualified young women would take these subjects if they were not discouraged from doing so. An additional number of able young women along with a number of able young men attend high schools offering a very limited curriculum in these subjects.

In 1946, more than 10,000 high-school science clubs with more than 250,000 members were stimulating interest in and further knowledge of science among high-school pupils through the Science Clubs of

Courtesy Science Service and University of Wisconsin Photographic Laboratory

Figure 14.—A 1943 Science Talent Search winner assisting in a cancer research laboratory in the summer of 1945 in the experimental production of tumors.

America (*23*). An interesting experiment in the discovery and development of scientific ability among high-school girls and boys has also been carried on since 1941 through the annual Science Talent Search, sponsored by the Westinghouse Electric Co. and Science Service, a nonprofit organization for the popularization of science. Science aptitude examinations are given yearly to any last-year student in a secondary school who writes an essay on a science topic and is certified by a teacher. From the 300 top-ranking contestants, 40 are awarded an all-expense trip to Washington, D. C., to attend a 5-day science talent institute to compete for the scholarships. Two scholarships of $2,400 each ($600 a year for 4 years) are given, one of them to a girl. Eight contestants receive scholarships of $400 ($100 a year); $3,000 additional may be awarded in scholarships at the discretion of the judges to the remaining contestants. Some 1,800 previous winners and honorable mentions have been assisted in obtaining other offers of scholarships and other financial assistance (*27*).

The percentage of girls earning the Washington trip is in proportion to the percentage of girls entering the competition. Thirty-one percent of the entries in the third and 28 percent of the entries in the fourth Searches were girls. The girls who were winners of the first three Talent Searches were preparing themselves in 1946 for the following professions: 11 as chemists, 5 as physicians, 4 as biochemists, 3 as astronomers, 2 as zoologists, 3 as mathematicians, and 1 each as a chemical engineer, biologist, physicist, psychologist, and anthropologist. Nine had their undergraduate degrees in 1946. One had already completed work for her master's and planned to begin on her Ph. D. in the fall of 1946. Three of the girls were in medical school; six of them had made Phi Beta Kappa, and one had been elected to Sigma Xi (*23*).

In 11 States, local organizations such as the State academies of science have sponsored concurrent science talent searches for high-school seniors in their respective States. A number of industrial firms also offer to high-school graduates college scholarships in science at universities in the vicinity of their main plants. Typical of these are the Bausch and Lomb scholarships at Rochester University and the George Westinghouse scholarships at Carnegie Institute of Technology.

These and similar efforts on the local level to encourage promising students have indicated the extent and the quality of the unmined scientific talent in the young women as well as the young men in our secondary schools. The direct relation of opportunity to the development of such talent is shown by the fact that certain States consistently failed to have top contestants in the Science Talent Search, while others had contestants in the honors group in proportions greater than expected on the basis of the numbers of their high-school seniors. The study indicated that these differences were related to educational and economic standards in the States (*10*).

Other large companies like the General Electric Co. and the Chrysler Corp., interested in encouraging the early discovery and development of scientific talent, have arranged intensive observation or training programs to acquaint high-school teachers and counselors with work in industry. The President's Scientific Research Board has recently discussed at some length the need to identify potential scientists early and has made some suggestions as to how this can be done (*48*). Certainly, parents, counselors, teachers, employers, and others whose advice may be sought by young women interested in science should be wary of discouraging the development of a talent that may be rare.

Earnings and Supply

Among research scientists, according to the President's Research Board, psychological satisfactions take precedence over financial rewards (*47*). The true scientist is likely to resemble Democritus when he said "Rather would I explain the cause of a single fact than become King of the Persians." He is more often found in a university teaching and working in fundamental research where salaries are relatively lower than he is in an applied science laboratory devoted to development or research for a single industry where salaries are usually better. He is more concerned about the quality of his laboratory equipment and assistance and with his freedom of thought and action than he is with the size of his income beyond that required for a reasonable standard of living. The limit to which the rest of society can go in exploiting this preoccupation, however, has been reached, judging from the number of scientists who left university teaching and research positions during the war and have not returned. The importance of basic research to society requires that it be recognized and rewarded as the well-spring from which much real wealth and employment flow.

Recent Nation-wide information on earnings was available for only a few of the scientific fields in 1947. But they are indicative. The median of the earnings of men and women physiologists, most of whom had a doctor's degree, was $5,050, in 1945. For the women, alone, the median was only $3,200. Only part of this difference can be explained by the fact that 17 percent of the women lacked the doctorate, while 2 percent of the men were without it (*4*). The median for a group of 110 women bacteriologists in 1947, three-fourths of whom had a master's or doctor's degree, was $3,400. The median of the professional earnings of 94 women engineers in 1946 was $3,576. That for a group of men engineers with comparable length of experience (approximately 8 years) was $4,320 (*11*). The most recent information on earnings of chemists dates from the end of 1943, when the median for women beginners was $1,884 a year as compared with $2,076 for men without experience; the highest paid group of women, those with 38½ years of experience, had a median of $4,512, while the median for men with experience of that length was higher by $840.

In other fields, too, the usual range of salaries for women as indicated by scattered reports was from $1,800 to $5,000, except for executive or other top jobs which reached, but seldom exceeded, $10,000. In a few fields, like astronomy, zoology, and biology, salaries as low as $1,300 were sometimes reported for beginners in some research institutions and medical laboratories.

In college teaching the range of salaries tends to be wide, varying with the size and wealth of the institution and not infrequently with the scarcity value of the particular instructor and his bargaining power.

A random sampling of one in six science teachers in colleges and universities accredited by the North Central Association of Colleges and Secondary Schools showed a range of salary from less than $2,000 to more than $7,000 a year in 1946. The median salary fell between $3,000 and $3,999, which was also the salary level in which the largest group was found. Two-thirds received less than $4,000 (*48*).

Courtesy U. S. Atomic Energy Commission

Figure 15.—A biologist engaged in the study of the effect of radiation on mammals at the Oak Ridge National Laboratory.

In 1946–47, the median salary of high-school teachers in cities of 100,000 and over was $3,593, that in small communities of 2,500–5,000 population was $2,274. The range was from less than $700 to more than $4,800 (*19*).

In the Federal Government in 1947, salaries were standard, being $2,644 for a beginning professional position (Ph. D.'s usually started at $1,400 more). The top ceiling in 1947 was $10,000, except for such exceptions as the Congress would authorize. The median pay for Government scientists as reported by the President's Scientific Research Board in 1947 was less than $4,500, while the average for those with a bachelor's degree was $4,637; for those with a master's degree, $5,104, and for Ph. D.'s, $6,340 (*47*).

ORGANIZATIONS OF SCIENTIFIC PERSONNEL

A network of organizations provides opportunity for scientists to advance and share their knowledge and to promote higher standards in their fields both in quality of scientific work and in working conditions.

More than 1,200 societies and organizations in the natural sciences and technology were listed by the National Research Council in 1942 (20). The principal organizations in each of the major scientific fields and the extent to which women participate in them are described in other bulletins in this series. Only the principal groups which bring together scientists in many fields are mentioned here.

The American Association for the Advancement of Science, originated in 1848 with an initial membership of 461, in 1947 had more than 33,000 individual members interested in promoting scientific work. A very small percentage, perhaps as low as 1 percent, were women, according to an estimate of the Association. Its 15 sections, each headed by a vice president, were: Mathematics, physics, chemistry, astronomy, geology and geography, zoological sciences, botanical sciences, anthropology, psychology, social and economic sciences, history and philosophy of science, engineering, medical sciences, agriculture, and education.

It served in 1947 as an integrating group for 203 affiliated and associated societies whose members totaled nearly 1,000,000, although there was of course duplication among them. Some 37 academies of science in States and cities were among the affiliated groups.

The National Academy of Sciences was incorporated by act of Congress in 1863 to advance science and to investigate and report on any subject of science or art whenever called upon by any department of the Government of the United States. There are 11 sections of the Academy: Mathematics, astronomy, physics, engineering, chemistry, geology and paleontology, botany zoology and anatomy, physiology and biochemistry, pathology and bacteriology, and anthropology and psychology. Membership is by election and is limited to 350. In 1947, only two women were members, one in the botany section and one in pathology and bacteriology.

The National Research Council is a quasi-governmental organization organized in 1916 by the National Academy of Sciences at the request of the President of the United States. It promotes research in the physical and biological sciences and encourages the application and dissemination of scientific knowledge for the benefit of the Nation. Its 220 members represent 85 national scientific organizations, Government agencies, and other research institutions and include a limited number of members-at-large. In 1947, 3 of its members were women, 2 in anthropology and 1 a nutritionist in the Division of Biology and Agriculture. The divisions of the Council are: Physical sciences, engineering and industrial research, chemistry and chemical technology, geology and geography, medical sciences, biology and agriculture, anthropology and psychology, foreign relations, and educational relations. Its Office of Scientific Personnel was in 1947 engaged in a study of the supply of Ph. D.'s in the sciences.

Among the many honorary and social fraternities in the scientific fields such as Sigma Xi and Tau Beta Pi to which a few women have been elected, there is a national graduate women's scientific fraternity called Sigma Delta Epsilon, the only woman's organization to be affiliated with the American Association for the Advancement of Science. In 1946 it had 15 chapters with about 500 active members. It furthers interest in science, provides for the recognition of women in science, and brings them together in a fraternal relationship. To be eligible for membership, a woman must hold a degree from a recognized institution of learning and must be, or have been, engaged in scientific research. A scholarship fund for women in science provides an annual scholarship, alternately predoctoral and postdoctoral.

In 1946 the Technical and Scientific Division of the United Office and Professional Workers of America, Congress of Industrial Organizations, successor to the CIO International Federation of Architects, Engineers, Chemists, and Technicians, announced its launching as an organization to cover "technical, scientific and salaried employees in industrial establishments, engineering and design offices, laboratories, and offices." Figures on national membership were not available, but the Washington representative reported 250 members in the Washington, D. C., chapter in December 1946.

THE DEMAND FOR SCIENTIFIC PERSONNEL

The demand for scientific personnel, as stated earlier, has been steadily increasing over the years in industry, Government, and educational institutions. Following a contraction from the war peak, particularly in industry and Government, the employment of persons trained in science has resumed its upward, peacetime trend. Although a full discussion is not warranted here, some of the factors tending to increase the effective demand for all scientists are noted briefly below, since an expanding over-all need improves the opportunity for women who seek employment in scientific work.

In Private Industry

In industry the demand is increasing, both for scientific research workers and for engineering and other personnel who need scientific training to do technical work required in the functioning of the particular industry or business. The need for the latter type of operating personnel sky-rocketed during the war, as industry not only expanded but functioned 24 hours a day. The postwar demand for engineers, control chemists, mathematical computers, vitamin assayists, and others included in this group fell below that abnormal peak but remained higher than the prewar demand. This is because the industries in which the proportion of such workers is relatively high have been steadily expanding over the years; for instance, the chemical industries, including the manufacture of pharmaceuticals, the foods industry, and the petroleum industry. Many small industrial companies, as well as some medical practitioners, have chemical and other routine testing done for them in commercial laboratories. These, too, have been increasing in number and were estimated at 250 in 1945. Expansion of construction, to make up for the lag during the depression years preceding the war as well as the wartime postponement of nonessential building, has accelerated the employment of architects and of civil engineers beyond the normal growth related to needs of the growing population.

In industrial research, the growth in demand has been more spectacular, from 3 industrial research laboratories in 1905 to 2,443 in 1946 (*43*) (*21*). According to one writer, this expansion should continue, since he estimated that there were 25,000 firms in 1945 which could and should maintain such laboratories (*29*). More significant

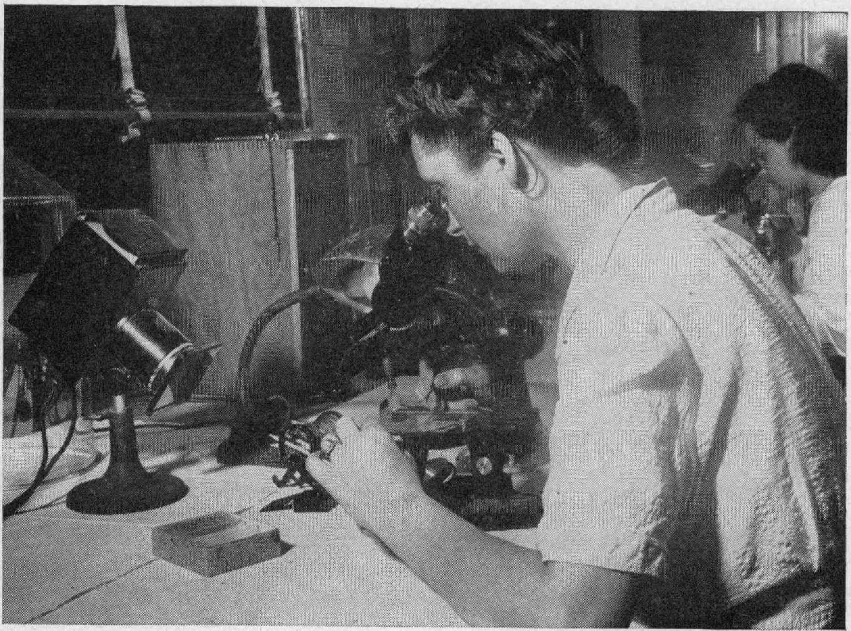
Courtesy Crane Company Research Laboratories

Figure 16.—A laboratory technician at work in an industrial research laboratory.

than the number of laboratories has been the increase in expenditures for industrial research. The amount spent by industry on research more than doubled from 1930 to 1940, when it reached 234 million (*45*). In 1947, industry budgeted 450 million for research. Expectations are that the growth will continue. One outstanding scientist recently noted three new trends in the attitude of industry toward research: An increasing interest in fundamental research, a more liberal interpretation of company policy, and an increasing tendency to cooperate with other companies in the industry or with universities (*7*). In addition to company laboratories, industry is using trade associations, university research services to industry, research institutions, and consulting laboratories for research projects (*50*). In 1946, as noted earlier, almost 55,000 scientific personnel and 35,000 additional technical personnel were employed in industrial research laboratories, an increase of 50 percent in the former and of more than 100 percent in the latter group since 1940 (*43*) (*21*). Chemistry and engineering continued to be the principal scientific groups among industrial research personnel, although all types of scientific workers were employed. The number of biological scientists in industrial research laboratories, including bacteriologists, increased 69 percent from 1940 to 1946, more than any other single major group.

In Government

The peacetime demand for scientific personnel by Government has been increasing even more rapidly than that in industry. State and local expenditures for laboratory personnel, particularly in the field of public health, and for engineers have grown. In addition, the Federal Government nearly tripled its expenditures for scientific research in the decade from 1930 to 1940 when they reached 67 million. During the war, of course, the Federal Government financed most of the 750-million-dollar national total of expenditures for scientific research, directed mainly toward developmental work on implements of war (*45*). Two years after the end of hostilities, however, the Federal Government was still expending approximately 625 million dollars for scientific research including research in atomic energy (*46*), and the Federal demand for qualified scientific personnel continued to be greater than the supply in some specialized fields. In 1947, the War and Navy Departments and the Public Health Service were unable to undertake certain research programs because of these shortages (*45*), and other projects were not completely staffed. The Office of Naval Research alone was spending 70 million dollars to finance scientific, including medical, research in universities and private institutions. In 1947, Federal Government research



Courtesy U. S. Public Health Service

Figure 17.—An entomologist checking infection of mosquitoes in a public health laboratory.

was primarily developmental, only 10 percent being basic or pure research. The President's Scientific Research Board recommended that Government expenditures for basic research be quadrupled by 1957, that those for research in health and medicine be tripled, and that those for nonmilitary developmental research be doubled (*45*). The provisions for a National Science Foundation made by the Congress in 1947, and vetoed by the President because he declared it to be administratively unworkable, included appropriations to be expended for scientific research by selected universities, research institutions, and other organizations (*49*).

Engineers on construction work, medical laboratory workers in veterans' hospitals, and other scientifically trained persons not engaged in research were also being employed in increasing numbers by Government.

In Educational Institutions

The demand for both teaching and research scientists has been growing and will continue to grow in institutions of higher education. According to the President's Scientific Research Board, science teaching staffs in 1947, although one-fifth larger than they were before the war, were not adequate for the 80-percent increase in students majoring in the sciences (*48*). Enrollments in science and engineering were so great in 1946–47 that the Board estimated that 15,000 more instructors in science and engineering were needed to restore the prewar student-teacher ratio, though that ratio was not necessarily a desirable one (*45*). Although some of this current demand is a temporary result of the attempt of men diverted from education to military service during the war to resume their academic training, the long-time trend in the demand for scientific training is definitely upward. Factors involved in this trend are:

(1) The higher educational requirements in scientific fields and in professional fields requiring training in the sciences, such as medicine and nursing.

(2) The growth in the general demand for education, due not only to an increasing population, but also to a constantly increasing per capita demand for education.

(3) Increasing emphasis on the teaching of science as a background subject for all college as well as high-school students.

(4) An increasing number of students from other countries who come to the United States for scientific training.

(5) Increasing scholarship and other financial aid to undergraduate and graduate students in science. Further assistance of this sort, to be financed by the Federal Government, has been

proposed by a number of authorities and was provided for in the proposed National Science Foundation legislation mentioned above (*44*) (*45*) (*49*).

Research as well as teaching programs in institutions of higher education have been increasing, although not so rapidly as those in industry and Government. In 1940, expenditures for scientific research by universities totaled 42 million as compared with 26 million in 1930. During the war, the universities spent less than 10 million a year, as most of their research personnel was diverted to Government projects. Since the war, the universities have been handicapped in resuming their usual research programs, almost three-fourths of which, before the war, were devoted to basic research. Research projects financed at universities by Government and industry usually afford higher incomes for the research staff, and these have been steadily increasing (*45*). About 300 colleges and universities in 1947 were conducting research projects supported in whole or in part by Federal funds. Most large universities had many small research projects for industry that in some cases ran into the hundreds. Many had established research programs or departments to coordinate such work and to promote cooperative effort (*7*). University research, particularly in basic science, would be greatly stimulated through a national science foundation similar to that proposed in 1947 (*49*).

Supporting Factors in Demand

Essential to the support of Government expenditures for scientific work, and in a large measure responsible for the increasing expenditures in privately supported research institutions, is the interest of the general public in science and scientific research. The personal contributions of the population to such medical research funds as those to fight infantile paralysis, tuberculosis, heart disease, and cancer evidence the increasing support available for scientific research. Attendance at museums, planetaria, zoological gardens, and scientific exhibits and the increasing demand for scientific publications, lectures, and classes are other indications.

The foreign demand for scientists and technicians from the United States, insatiable since World War II, is also a factor. Other countries, relatively undeveloped industrially or set back by the devastation of war, were attempting rather unsuccessfully in the face of the local demand to recruit chemists and engineers from the United States. This foreign demand is expected to continue for some years.

Tending to reduce the demand, on the other hand, technology and ingenuity are as constantly at work in the laboratory as in the factory, making it possible to do more work with fewer people. Computing machines, particularly, and a variety of automatic testing and counting machines have eliminated many man-hours of work. But to the scientist, his own release from such routine, as well as that of members of his staff, does not mean unemployment but a chance to explore farther into the great unknown or to perform more adequately the testing or other functions assigned him. For behind all current demand for scientifically trained persons backed by financial support stretches what has been called by the head of the wartime Office of Scientific Research and Development "The Endless Frontier" (*44*).

Each addition to scientific knowledge opens other vistas that lure the true scientist ever onward. This is true not only in physics, which is popularly considered "the science" of the moment because of the atomic energy development, but in all scientific fields. For example, it is being said that "* * * recent biological discoveries have opened a totally new realm of technical development" (*25*) (*30*). And a physiologist wrote in 1946, " * * * only an infinitesimally small fraction of the reckoned possible aspects and processes of organisms have yet been studied" (*1*).

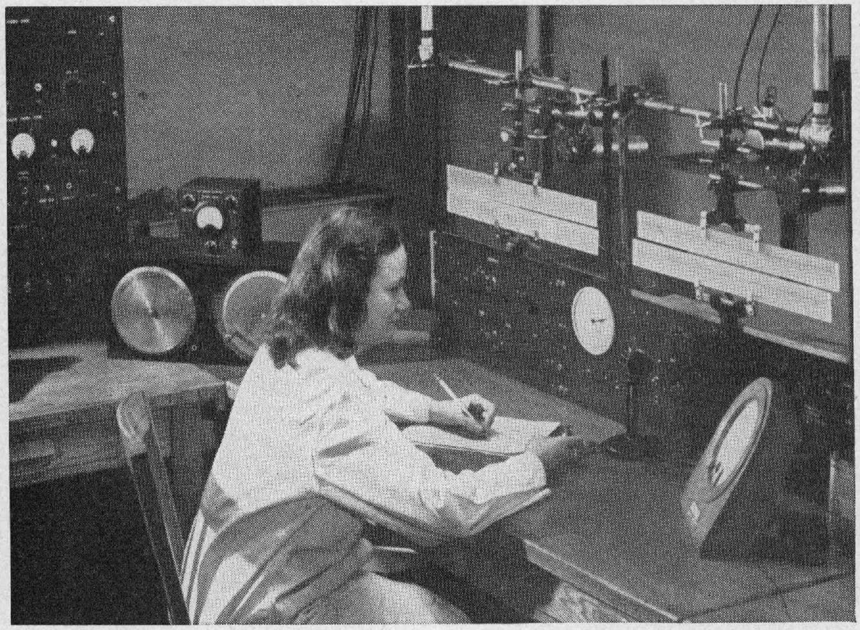
The 10 most important advances in science during 1947 in the opinion of the director of Science Service indicate the lack of monopoly on progress by any one of the scientific fields as well as their interrelationships:

1. Discovery that smell is detected by infrared radiation absorbed by odor material reaching the nose.
2. Pilotless plane that crossed Atlantic untouched by human hand at controls.
3. Attempts at artificial rain making through sprinkling dry ice or water on clouds under certain conditions.
4. Synthesis of protein in long-chain molecules, promising new plastics of medical and industrial importance.
5. Interconversion of proton and neutron fundamental particles and smashing of many more elements yielding new isotopes and transmutations in world's highest voltage synchro-cyclotron.
6. Largest display of sunspots in over a century.
7. Use of streptomycin in tuberculosis treatment.
8. Development of jet bombers and higher speed jet planes.
9. Discovery of 10,000 year-old Tepexpan man in Mexico.
10. Camera that makes finished photoprint in one-step process.

The head of a great engineering laboratory in 1944, speaking of the abilities of the engineer for providing "more goods at less cost for more people to use," called attention to the fact that, even in the years from 1929 to 1939, which included a major depression, engineers and scientists developed among other things: Transoceanic passenger air service; fluorescent lighting; glass building blocks; synthetic rubber, hosiery, and vitamins; sulfanilamide; and many new plastics (*24*). "The real ceiling on our productivity of new scientific knowledge and its application in the war against disease, and the development of new products and new industries, is the number of trained scientists available," said the head of the Office of Scientific Research and Development in 1945 (*44*).

Beckoning the ablest young men and women scientists of the future are such problems as those listed below:

The utilization of atomic energy,
Creation of national low-cost housing,
Synthesis and improvement of the antibiotics,
Creation of an electrical standard of living in the home,
The control and prevention of some kinds of cancer,
Discovery of the secret of photosynthesis,
Cure for the common cold,
Extension of electricity to the farm,
The use of electronics in medicine,
Discovery of the true structure of the protein molecule,
Application of radioactive isotopes,
The development of microwave transmission (*14*) (*24*) (*31*).



Courtesy U. S. Atomic Energy Commission

Figure 18.—A physicist at the control console of the chain-reacting pile at a laboratory of the U. S. Atomic Energy Commission.

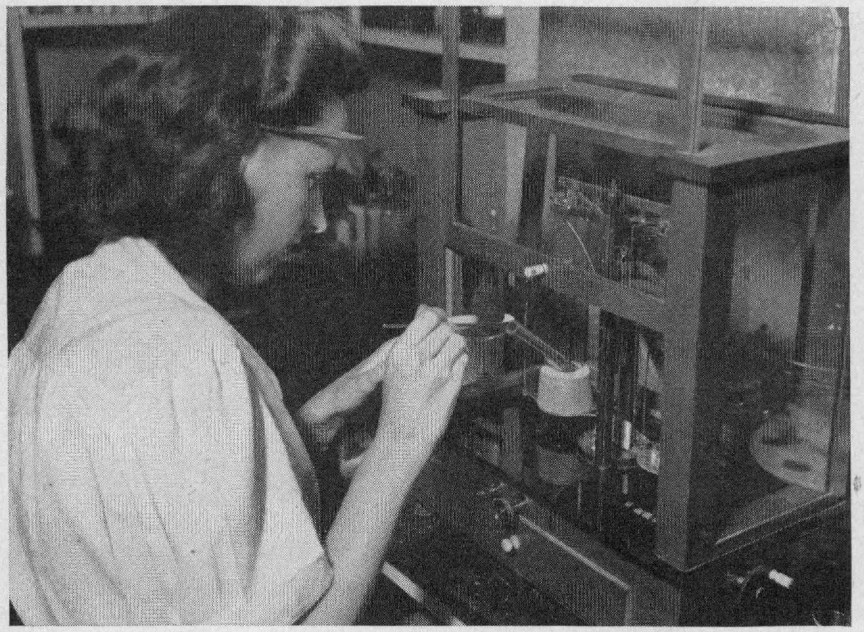
THE OUTLOOK FOR WOMEN IN EACH OF THE PRINCIPAL SCIENTIFIC FIELDS

The gap between the supply of scientifically trained persons and the demand for them, which was in some cases created and in some widened by World War II, became more marked in some scientific fields than in others. In some, too, it will be bridged more rapidly than it will be in others. The other reports in this series discuss the relation of supply to demand in each of the principal fields and its effect upon women's opportunities for training and employment. Here, only a brief, simplified summary is given for purposes of comparison.

Outlook for Women in Chemistry

The largest number of positions for women trained in nonmedical science will continue to be in the field of chemistry, where more than 5,000 women were employed in 1946. Although this was three times the number of women employed in chemistry before the war and although more women are studying chemistry than ever before, their numbers were still too small in relation to the total to be a major factor or problem in supply. In this largest scientific field for them, women are distinctly in a minority position, numbering about 6 percent of the total. The demand for well-trained women in chemistry, though far below that of the war peak when even poorly trained persons could obtain work, will continue in educational institutions, in industry, in Government, and in research centers. Women Ph. D.'s, remaining scarce, will be in demand for college teaching or research, especially for basic research or applied research in medicine or foods lines. The great majority of women with bachelor's degrees will be engaged in analytical chemical laboratory work in industrial or medical laboratories. They will be found in every type of industry, but in largest numbers in chemical manufacturing, foods, and petroleum and coal products industries. Another sizable group will become secondary-school teachers of science. The large, unmet demand for women trained in chemistry for related work as teachers, librarians, editors, and secretaries will act as a cushion to any possible, but unlikely, oversupply of women trained in chemistry.

For further information, see Bulletin 223–2.



Courtesy U. S. Department of Agriculture

Figure 19.—A chemist running a sample of DDT into a microdispenser tube for weighing.

Outlook for Women in the Biological Sciences

Although in all there are only about 2,500 women in the biological sciences, less than half the number of women in chemistry, women have played and will continue to play a relatively larger role in such fields as bacteriology, general botany, and general biology. In bacteriology, particularly, where they already number one-fourth of the total, there is a growing demand for their services especially in teaching and in medical laboratories and to some extent in the foods and drugs industries. The use of antibiotic drugs has created a new and continuing demand. Growth in medical research will increase opportunities for women bacteriologists, although the tendency to prefer the M. D. in medical research somewhat limits opportunities in that field for those who do not possess it. In general botany where they number one-fifth, women are in demand principally as teachers, although there is a much wider variety of work in which there are opportunities for small numbers. In general biology, where they number one-fifth, and in general zoology and physiology, where they number slightly less, the principal demand is for teachers and for medical laboratory workers. In all these fields, graduate training is virtually necessary for most work, except for technicians and assistants in medical laboratories and for high-school teaching jobs. For industrial laboratory work, for much of the medical laboratory work, and for many high-school teaching jobs, a knowledge of chemistry particularly, or, in some cases, physics or mathematics, is needed in addition to training in biological science. Only a few women have pioneered in the related agricultural sciences. In poultry and animal husbandry, horticulture, agronomy, and forestry, for example, they compose less than 1 percent of the total. Except in forestry, where isolated field work is common, there is nothing in the nature of these sciences that should deter women from their study and practice. More women can be absorbed in these related fields, but they must be well-trained and adaptable to an extreme minority situation.

For further information, see Bulletin 223–3.

Outlook for Women in Mathematics and Statistics

In mathematics as in some of the biological sciences, women form the relatively high proportion of about one-fifth of the total. They number a little more than 2,000, if those engaged in statistics and the large number of mathematics teachers who have not majored in mathematics are excluded. The principal demand for women in mathematics will always be in teaching, both at the college level, for the more highly specialized group, and at the high-school level, for the bachelor's group. A small industrial demand, much reduced from the wartime peak, will continue for computers, principally in public utilities and in such firms as those manufacturing instruments, metal and metal products, and electrical, communication, and transportation equipment. Opportunity will be greater for those who are also trained in chemistry or physics. Insurance companies will continue to be a principal source of demand for mathematical and statistical clerks.

Women thoroughly trained as mathematical statisticians will find ample opportunity in industry and in Government in this relatively new field. At the top levels of mathematical research and as actuaries, women will continue to be rare. It is probable that the few women preparing themselves for such work in the future, as in the past, will have enough ability and motivation to hold their own.

For further information, see Bulletin 223–4.

Outlook for Women in Engineering

Women in engineering, forming much less than 1 percent of the total number, are still considered pioneers. Yet this field ranks between bacteriology and physics in the number of women it employs—more than 900. The tremendous wartime emphasis on engineering encouraged more women to enroll in engineering schools and likewise resulted in a postwar doubling of the prewar enrollments of men in engineering schools. Indications are that the supply will overtake the demand more quickly in this field than in the others. Competition for engineering jobs, therefore, is likely to become keen within a few years. However, most women engineers in the past have worked out unique jobs for themselves in directions where they have a natural advantage. Others have used their engineering training as background for technical editing and writing or patent work. The variety of their work in all fields of engineering is indicated in Bulletin 223–5. There will continue to be a place for women of ability and imagination in engineering.

For women engineering aids, on the other hand, the demand has virtually disappeared and is not likely to be revived so long as young inexperienced male engineers are available to do this work as part of their in-service training. Only a few jobs of this nature in which continuity is important will remain open to women, but more often under such titles as computer or engineering draftsman.

For further information, see Bulletin 223–5.

Outlook for Women in Architecture

Although women architects, numbering 300, are only one-third as numerous as women engineers, they have been more conspicuous for two reasons. In the first place, the proportion they form of their professional group, though only 2 percent, is considerably higher than the 0.3 percent women compose of all engineers. In the second place, like men architects, they are as likely as not to be practicing independently.

In this field, for which even fewer women prepared during the war than before, the immediate outlook is good because of the expected increase in construction to make up for wartime and depression lags. Women architects who wish to practice independently, however, face the problem of building up a reputation in a field which requires a triple combination of abilities: scientific, artistic, and business. Some may prefer to specialize in the newer fields of community or city planning or public housing.

For further information, see Bulletin 223–5.

Outlook for Women in Physics

In physics, where women approximate 900 and form about 5 percent of the total, employment should be fairly easy to obtain in the next 5 to 10 years at least. This is especially true for the woman Ph. D., since the marked undersupply evident in Government and in industry in 1947 was expected to prevail for some years. Teaching will furnish by far the largest number of openings for women both in college, where graduate training is usually necessary to qualify, and at the high-school level, where it is customary to teach another science or subject as well. In industrial and Government laboratories, the demand for women, though considerably smaller than that in teaching, will continue, especially for the Ph. D. but also for laboratory workers who are well-trained not only in physics but in chemistry or mathematics as well.

For further information, see Bulletin 223–6.

Outlook for Women in Geology

In geology, where less than 300 women were employed in 1946, future opportunities for women will resemble those of the past. Teaching will absorb the largest group, while State and Federal Government and industry will employ most of the remaining number. In industry and in Government ,with few exceptions, women geologists will be limited to laboratory or desk jobs in connection with which field work is rare.

For further information, see Bulletin 223–7.

Outlook for Women in Geography

The impetus given to geography by World War II has tended to increase opportunities for women in this relatively small field in which they already form one-sixth of the total. In colleges and universities, where about half of the 140 women trained as professional geographers were employed in 1946, the demand was increasing, as it was in other schools, where about one-fourth of them were employed. In the Federal Government and in industry, there will continue to be a small, steady demand for professionally trained geographers for cartographic work and geographic research, writing, and editing. In this field, graduate training is necessary to qualify.

For further information, see Bulletin 223–7.

Outlook for Women in Astronomy

In astronomy, where women comprise about one-sixth of the total, the Ph. D. is a virtual necessity, except for computing work. Women will continue to find occasional openings in college teaching and research at observatories. Outlets in this field, however, are characteristically few, and turn-over is low. On the other hand, the number of women trained in this field is also small, totaling about

100 in 1947. Those who can teach mathematics and physics as well as astronomy will be in greatest demand.

For further information, see Bulletin 223–6.

Outlook for Women in Meteorology

Although large numbers of women were trained as weather observers during the war, and hundreds were still so employed in 1946, only a handful of women, probably no more than 30, were qualified or working as professional meteorologists in 1946. Men will continue to be very definitely preferred in this field, which is steadily growing in importance but for which thousands of men and women received at least partial training during World War II. For the few women specializing in this field, however, there will be limited opportunities in teaching, writing, and research.

For further information, see Bulletin 223–7.

Courtesy U. S. Weather Bureau

Figure 20.—A meteorologist making computations she will use in preparing training material for weather forecasters.

VARIATIONS IN THE OUTLOOK FOR WOMEN IN SCIENCE

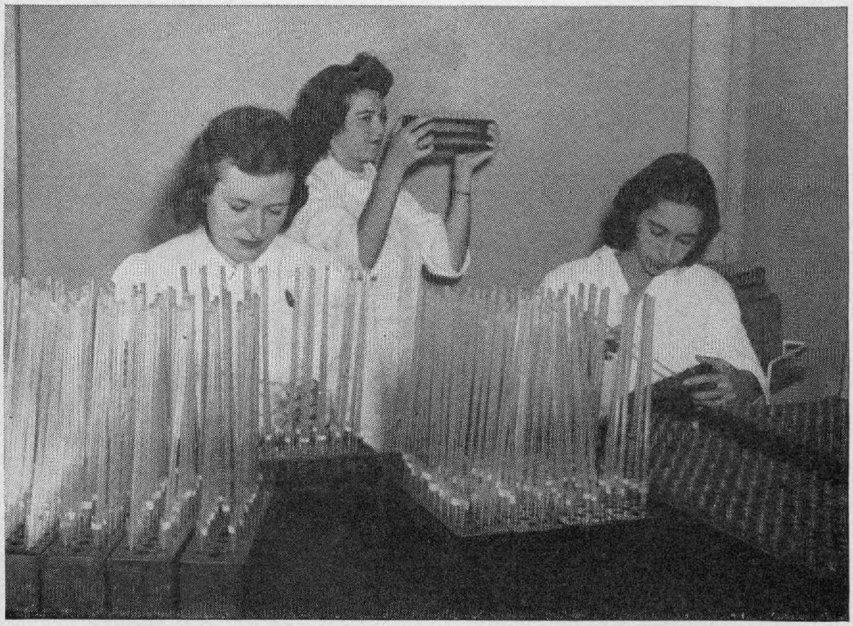
Just as the opportunity for employment and progress is greater in some scientific fields than it is in others, so within a given scientific field or specialization, the prospects for individual women vary, not only with their aptitude and training for the work but also with their location and their characteristics. These variations, as noted below, should be considered in relating information of the type presented in these bulletins to the employment or training plans of an individual woman.

Geographic Variations in the Outlook

Opportunities for employment in science are not equally good in all parts of the United States. Although this fact presents no problem to the woman who can move to any locality in which jobs are available, it is significant to the woman who, because of home or other responsibilities, is tied to a particular area. One of the differences between young men and women noted by many employers of scientific personnel was the tendency of the women to prefer jobs within 25 to 50 miles of their homes. To what extent this preference is prompted by choice, to what extent it arises out of necessity, is not known. But other studies of the Women's Bureau indicate that the responsibilities of single as well as of married women for financial aid or for personal services to the other members of their families are considerable. Improvement in labor-saving devices which reduce homemaking tasks, a greater supply of practical nurses and household service workers, higher family incomes, and further improvements in transportation facilities over the long-run will improve the occupational mobility of women. Meanwhile, lack of mobility limits the individual's choice of jobs and makes a woman a less desirable employee on jobs where travel or probable transfer may be involved.

Most scientific work is concentrated in cities where medical and industrial laboratories are located or in college or university towns or cities where scientific research and teaching are carried on. This is true, for example, of the work of most chemists, engineers, bacteriologists, and physiologists. It is also true of the proportionately large teaching groups within the fields of botany, zoology, and geography. The principal exception to this generalization is work which involves the location, study, or treatment of organisms or objects in their natural environment, if that environment is limited to certain areas. The marine biologist, the regional geographer, the field geologist, the mining engineer, the forester are occupations in which travel to, or location in, remote places is likely to be characteristic. Women with limited mobility should avoid such occupations.

In astronomy and meteorology, employment is confined to a relatively few centers of research or observation. In geology, where field work is also a deterrent, employment, except in teaching, is concen-



Courtesy U. S. Public Health Service

Figure 21.—Medical laboratory technicians at work in a hospital.

trated in the oil-producing States of Texas, California, Louisiana, Kansas, and Illinois and in Federal and State capitals.

Chemists and bacteriologists, on the other hand, are found in every large community. Hospitals, medical schools, and public-health laboratories as well as widely dispersed dairies and other food plants and chemical manufacturers employ them. However, quantitatively, because of the concentration of large manufacturing industries, there are greater opportunities in some parts of the country than in others.

Before the war, according to the Census, almost three-fourths of all chemists were employed in the Northeastern or North Central States; the South ranked third and the West last with one-tenth of the total. The proportion of women among chemists in the various sections of the country was highest in the Northeastern States (3.5 percent), and lowest in the South (2.3 percent). (See Bulletin 223-2 for detail.)

This prewar concentration of employment opportunities for chemists in the Northeastern and North Central States was confirmed in the 1943 study of the Bureau of Labor Statistics (*36*). The State of New York alone employed 13.5 percent of all chemists; Pennsylvania, New Jersey, and Illinois ranked next. The Middle Atlantic States of New York, New Jersey, and Pennsylvania absorbed as many as half the Ph. D.'s produced in chemistry in the entire country during the period 1930-1940 (*15*).

The geographical distribution of the physiologists surveyed in 1945 shows the direct relation of the demand in that field to the location of medical schools. Nearly one-half of the physiologists were in New York, Pennsylvania, Illinois, California, and Massachusetts, where one-third of the country's medical schools and 42 percent of its medical students were located. No physiologists were reported from three other States in which there were no medical schools (*9*).

Allowances for this type of variation in the location of employment should be considered by young women who intend to work in a scientific field outside of teaching and who are restricted by circumstances to a given area.

Variations for Women With Special Employment Problems

The difficulties individual women may encounter in entering an occupation are legion and vary with the person and the circumstances which surround her. But there are four large groups of women who are likely to encounter special problems in obtaining employment in most fields. The older woman, the married woman, the Negro woman, and the woman with a physical handicap often find that their opportunities do not follow the usual pattern.

Older Women.—Among those registered in the physical and biological sciences and in engineering and in architecture with the National Roster of Scientific and Specialized Personnel at the end of 1946, 325 women and more than 21,000 men were 60 years of age or older. However, the median age of the women in each of these scientific groups was 7 to 9 years lower than the corresponding median for the men, which ranged from 35 in the physical sciences to 48 in architecture, with the other two groups at 40 (*38*). This relative youthfulness of women reflects the greater withdrawals of women before retirement age, due to marriage and family reasons, rather than lack of opportunity for the older woman already established in her field. In research and teaching, there is virtually no age limit for the scientist with long experience who has kept abreast of new developments in her field.

But the woman who wishes to enter a scientific profession at the age of 30 or 40 or the one who wishes to reenter after some absence has a different problem. During the war, the demand for women trained in science was so great that a woman in the forties who had had any training in science or engineering or any laboratory experience, regardless of its recency, could obtain work, though often at a level below that of her training. A woman civil engineer, after 25 years of absence from her profession, for example, returned as a draftsman with a Federal agency while her husband was in military service. Many former chemists likewise returned to the laboratory. However, ordinarily, it is difficult for a woman over 40 to do laboratory work, whether it be in chemistry, bacteriology, botany, zoology, or geology, unless she has worked continuously in a laboratory and has retained her manipulative skill. Even teachers of science may lose this skill which only daily experience can maintain.

Except in college teaching and in research, which "knows no age limit" according to one laboratory director, and in which evidence of work done is the main criterion, young women are definitely preferred to older women for entering jobs both in industrial firms and Government agencies. Most of the women over 40 and the few over 50 found in the Women's Bureau study of laboratories had been with the same employer for many years. A few had been hired during the war period, either because they had a certain type of specialized experience wanted by the employer or because younger women were not available. The constant standing in most laboratory work, the importance of adaptability and of manipulative skills, and the recent and rapid changes in the sciences are the usual reasons given for preferring young women. Stamina, spryness, and the ability to withstand inclement weather are needed in meteorological observation and scientific jobs entailing field work, and for this younger persons are preferred. Extreme youthfulness, however, may also be a handicap. Several employers reported that most of the girls under 21 whom they had hired for chemical laboratory work during the war were not as reliable as women over 30, although they were faster. Their turnover rate was also higher.

Opportunities, then, are good for older women who have worked continuously as college teachers or as research scientists and who have kept abreast in their fields. For the less highly trained or less experienced woman, they may be limited to her specialty and perhaps to her employer, if her field is not one for which there is an active demand.

The woman who wishes to return after a considerable absence faces two obstacles. She must catch up with the many changes the intervening years have brought in her field. And she will find laboratory work both difficult to obtain and difficult to do. Technical library work, patent searching, or editing are better possibilities for a woman of this type, if she can qualify for such work.

There are always exceptional women and exceptional circumstances, however. One woman, long out of school, became interested in medical laboratory work through the illness of her husband. She took training in New York and became an outstanding research assistant in a medical laboratory there. Another, after 15 years of teaching experience, took a degree in architecture and practiced successfully until her retirement. To prepare for and enter a scientific field after the age of 30, however, is seldom desirable for any woman unless she has had fairly continuous training or experience in a related field such as medicine, nursing, or the textile or foods phases of home economics.

Married Women.—The fact that many of the women covered in this study were married indicates that homemaking can be combined with

Courtesy University of Cincinnati

Figure 22.—Among the women scientists who are also homemakers is this bacteriological research worker whose husband, like herself, was graduated as a chemical engineer and whose daughter is studying science.

a full-time job in science. No census statistics are available, however, to show how women in science compare with women physicians or other occupational groups in this respect.

In chemistry, physics, mathematics, and the biological sciences, married women usually encounter no special difficulties in obtaining or retaining employment. For the most part, hours in these fields are regular, and the places of employment are distributed throughout the country. In the smaller fields of astronomy, geology, and geography, however, the concentration of employment opportunities in certain locations may be a factor in reducing the married woman's opportunity for employment in her field, since the location of her home is likely to be determined by her husband's employment. The field work required from time to time in geology or geography also may handicap the married woman responsible for the maintenance of her home as well as her job.

In meteorological Government and air-line stations where forecasters are often required to work at night and on rotating shifts, a married woman would find the schedule difficult. However, those engaged in research or teaching would have more regular hours like other college instructors or research workers. In fact, science teaching at the college level apparently combines well with marriage. In secondary-school teaching, the restrictions against married women observed in some communities before the war have greatly diminished in view of the shortage of well-qualified teachers, which has been especially acute in science and mathematics.

Women in scientific work frequently marry men in the same line of work. One employer said that a chemistry laboratory is a most fertile field for marriage, because men chemists are too serious and absorbed in their work to engage in much purely social activity and are likely to marry intelligent, attractive girls employed in the laboratory. In geology and astronomy and in field work jobs in the sciences, marriage to a scientist in the same field enables a woman to continue the practice of her profession and often to do field work that would otherwise be difficult to arrange. There is also convincing proof that marriage and engineering can be combined. Of the dozen women listed in Who's Who in Engineering, four are married, and three of these have at some time carried on joint professional activities with their engineer-husbands.

Most of the employers of scientific workers interviewed by a representative of the Women's Bureau in 1946 and 1947 reported that marriage made no difference in the status of women employed in scientific or technical work, except that it increased the likelihood of turn-over, particularly in the younger group. In hiring, other qualifications being equal, they would prefer a young single woman.

However, one expressed a definite preference for stable, married women; another preferred women, single or married, who "had dependents and would stick to the job better." Almost all indicated that the comparatively rare woman who had shown by her training and her work that she was seriously interested in science as a career would be employed regardless of her marital status.

That marriage also does not prevent the attainment of distinction in science is indicated by the fact that some of the outstanding women scientists in the country are married. Many of the women listed in American Men of Science and in the Chemical Who's Who, for example, are married. Three of the five women who received postdoctoral National Research Council fellowships in chemistry in the period 1919 to 1938 were married, as were 5 of the 14 who received similar fellowships in zoology (*22*).

Negro Women.—Negro women face many problems not only in securing employment in the field of science but in obtaining adequate training. Although most of the 32 Negro colleges included in a 1942–43 study offered courses in biology, chemistry, physics, and mathematics, these courses were reported to be usually unrelated to vocational objectives except in the premedical curriculum (*33*). Courses in geology and astronomy were rare. Negro women interested in advanced training have often been limited in their selection to a few Negro universities, or to women's colleges and State universities or other coeducational schools in the North with larger departments of science.

Only 48 women were among the 368 Negroes who received a Ph. D. in the years from 1876 to 1943, according to a recent study (*13*). About one-fourth of the 368 doctorates were in science, but only a few of these were awarded to women. Most of the 58 doctorates granted in the physical sciences were in chemistry; physics and mathematics accounted for most of the others. Only one Negro woman, who received her degree in geology, was among those receiving the doctorate in a physical science. However, at least one other has since been awarded the Ph. D. in mathematics.

Most of the 35 Ph.D.'s granted to Negroes in the biological sciences were in zoology and biology, with a few in bacteriology, physiology, and botany. At least four Negro women are known to have earned the doctorate in the biological sciences. A larger number have earned master's or bachelor's degrees with a science major, but no statistics are available on their number.

Negro women who have secured graduate training in science find opportunity for employment largely in high-school and college teaching. In a count made by the Women's Bureau in 1947 of women on college faculties in science, 50 women were found listed in the catalogs

Courtesy Miner Teachers College

Figure 23.—A geologist and associate professor of geography who has the distinction of being the first woman and the first Negro to receive a doctor's degree in geology at Catholic University of America.

of 31 Negro colleges which were considered by the United States Office of Education as representative in their enrollment of the 105 Negro institutions of this type in the United States. Seven of the women held professorial appointments, ranging from that of assistant professor to that of full professor. The others were either assistants or instructors.

One-third of the women were teaching two or more subjects. Biology and mathematics alone or in combination with another subject accounted for two-thirds of all the teachers, while only one-sixth taught a physical science. If the faculties of these 31 schools are truly representative of all Negro institutions of higher education in the United States, approximately 169 women were teaching science or mathematics in Negro colleges and universities in 1946–47. A larger, but unknown, number of Negro women were teaching at the secondary-school level. The high proportion entering high-school teaching is indicated by the employment of 26 women who were graduated by Howard University in the years 1940 to 1946 with a master's degree in botany, chemistry, mathematics, or zoology. Eleven went into high-school teaching, six into college teaching, four into the Government, two into hospital laboratories, and the remaining three took miscellaneous positions or married.

Opportunities, other than teaching, for Negro women trained in chemistry or the biological sciences have been most numerous in hospital or other medical laboratories where they have served as technicians. A few have taken further training for such related fields as medicine or pharmacy.

Although industry and Government have been difficult fields for Negro scientists to enter, Negro women are known to be employed as seed analysts, technicians, or chemists in at least two regional laboratories of the Federal Government and in one laboratory in Washington, D. C. In one of the industrial firms visited in the course of this study, one Negro woman with a college degree in chemistry was employed as a chemical tester on control work in steel. A midwest university in 1946 placed with an oil company a young Negro woman chemist who was married and whose husband was studying medicine. An unknown number of Negro women took chemistry courses under the Engineering, Science, and Management War Training program and worked in war industries. One who took a 10-week analytical chemistry course at a woman's college under this program was reported to be a "whizz on carbons."

Although there were only about 300 Negro chemists, 240 Negro engineers, and about 80 Negro architects reported in the Census of 1940 (*34*), there are opportunities for Negro men and women trained in these fields. A prewar study of Negro men chemists indicated that, besides those in teaching, at least 40 were employed in 1940 in various types of laboratories, one serving as a director (*51*). In 1946, the National Technical Association, an organization of Negroes engaged in scientific or engineering fields, had more than 500 members, most of them in engineering (*2*). Although women in these fields are rare, at least one Negro woman has received a bachelor's degree in civil engineering from Howard University. As more Negro engineers practice, positions as office engineers may open up for the few women who may train for this field in the future. Two or three Negro women were employed as draftsmen in one of the Federal agencies in 1947. A few Negro women have also been successful in architecture, a field in which, in 1946–47, five women students at Howard University were majoring.

However, the Negro woman who would seek employment in a scientific field must have thorough training in order to compete with men of richer scientific backgrounds. The costs of scientific training are high, but scholarships and assistantships are available to students of outstanding ability. A recent article on Financial Aids for Education and Chemical Research lists a number of scholarships and fellowships, for which Negro students are eligible, such as the Julius Rosenwald fellowships, the General Education Board fellowships, and the Guggenheim Memorial fellowships (*12*).

Women with Physical Handicaps.—The free use of elbows, hands, and fingers, as well as good enough vision to read measured distances on scaled laboratory equipment, and the ability to distinguish basic colors and shades are required of men and women taking certain civil service examinations, as laboratory worker, for example, in the field of chemistry. Ability to hear others in the laboratory with ease is also important in most, but not all, laboratory work. In a foods laboratory visited by a representative of the Women's Bureau in 1946, a hard-of-hearing woman chemist who could read lips was employed. A totally deaf entomologist who could read lips was also found employed in a biological supply house.

Although most laboratory work requires much standing and moving about, some routine jobs can be handled from stools, and crippled persons may be employed at this sort of work. Two pharmaceutical firms reported the satisfactory employement of lame girls as laboratory technicians or helpers. Of course, in the office phases of engineering and architecture, in drafting, and in mathematical work, limitation of movement and deafness would be much less of a handicap than in most laboratory work. The Coast and Geodetic Survey in 1946 employed one woman and one man draftsman with hand injuries, usually a much more serious work handicap than a leg injury. In scientific work involving field service, however, such as that often characteristic in geology, forestry, and geography, lack of mobility is a serious handicap. Teaching, the editing of reports, and technical library work are good outlets for persons with scientific experience who become limited in their movement by poliomyelitis or similar handicaps. Two men with polio handicaps were found employed as technical librarians in the laboratories visited.

For those who have physical conditions requiring frequent checking, such as certain types of cardiac or tuberculosis cases, employment in a hospital or other medical laboratory under controlled conditions would be more desirable than work in industry. Of course, consultation with a physician or a rehabilitation specialist is advisable for a woman with a physical handicap who is interested in scientific work.

Good vision and good health are perhaps the two most important physical qualifications in most types of scientific work, which inevitably involves the ability to observe accurately and the stamina to persevere at a difficult task, regardless of circumstances.

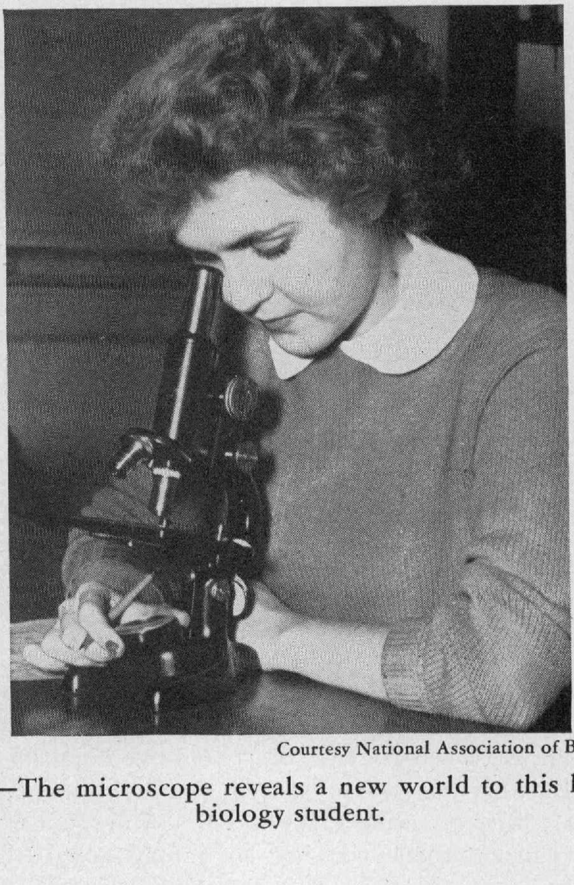
SUGGESTIONS TO GIRLS AND WOMEN INTERESTED IN SCIENTIFIC WORK

"Shall I prepare for a job in science?" This question will be asked countless times in the future as it has been asked in the past by starry-eyed, serious young women.

Some of them will be told, "That's no field for a woman." Others may be advised, "Of course! Don't let anyone stop you. You may become a second Marie Curie." Between these two extremes lies the broad realm of possiblity, as shown in the expanding variety of scientific work in which women are engaged.

Exploration and Choice

This is a realm that each individual must examine for herself as early as possible, selecting the probable areas which interest her most,



Courtesy National Association of Biology Teachers

Figure 24.—The microscope reveals a new world to this high school biology student.

using the charts and reports based on the experience of those who have gone before. The information given in the bulletins in this series and in those on occupations in the medical and other health services (Women's Bureau Bulletins 203–1 through 203–12) should be useful in this exploration. But they should be supplemented by current reports, first-hand whenever possible, from women and men engaged in scientific work or in the training or employment of scientific personnel.

The autobiographies of women who have achieved public recognition in the sciences accent the heights that may be attained. Brief biographical summaries of the more than 2,000 successful women included in the 1944 edition of American Men of Science show that no one scientific field has a monopoly on opportunities for women to earn distinction (*5*). This is shown in the distribution of the 1,686 women who listed themselves primarily in one of the principal scientific fields covered in this study. (See table 7.)

Table 7.—*Distribution of Women Listed in American Men of Science, by Scientific Field, 1944*[1]

Scientific field	Number	Percent
Total	1,686	100.0
Astronomy	35	2.1
Bacteriology	122	7.2
Biology, general (exclusive of bacteriology, botany, zoology)	108	6.4
Botanical Science	270	16.0
General botany	222	13.1
Plant physiology and pathology	40	2.4
Agricultural plant sciences including forestry	8	.5
Chemistry	430	25.5
Engineering	5	.3
Geography	16	.9
Geology	55	3.3
Mathematics (exclusive of statistics)	163	9.7
Physics	92	5.5
Zoological Science	386	22.9
General zoology	244	14.5
Physiology	103	6.1
Pathology	38	2.2
Animal husbandry	1	.1
Miscellaneous sciences	4	.2

[1] This table covers more than ¾ of all the women listed. An additional 489 women gave as their principal fields: Medicine, psychology, education, social science, or other categories not included in this bulletin.

Source: American Men of Science, 1944 (*5*).

The prevalence of Ph.D.'s among the women listed in American Men of Science and the records of their experience show the length of the road and the consistency of effort that are required to reach the heights. Even genius is not spared the discipline and drudgery required for success in science, as the years of devoted work of Marie and Pierre Curie in their makeshift laboratory show (*8*). The rigors of the journey to the top require not only aptitude for science but strong motivation, courage, and stamina.

The prominence of the great men and women in science, like the peaks on a relief map, attracts attention away from the plains and the plateaus, where the majority of women trained in science are working. But the seeker will find great variety in the landscape and more than one location suited to her interests and abilities.

The wide range of the sciences, the specializations within each scientific field, the variations in types of work and in employing agencies (as indicated in the bulletins in this series) multiply the possibilities for a potential worker in science but also complicate the problem of her choice. The earlier the potential young scientist examines herself and her limitations in relation to the varied possibilities, the more surely will she arrive, prepared and ready for useful work, at a location that suits her and her circumstances.

She can narrow down the territory she wishes to explore more thoroughly by certain eliminations. Some may be on the basis of required abilities, the possession or lack of which may be verified with the assistance of counselors, teachers, and others qualified to supply perspective on her abilities in relation to those of others. Other eliminations may be on the basis of personal circumstances and preferences, such as the necessity or desire to work near home, the likelihood of early marriage and the cessation or interruption of outside work, or inability to finance the training required.

In weighing one's circumstances, it is important not to let present handicaps obscure future possibilities. The scientifically talented young woman who changes from a scientific to a business course in high school only because she does not at that time see any possibility of a scholarship in college places unnecessary limits on her future. It is usually possible, with careful planning, to face the immediate situation without turning one's back completely on the ultimate goal.

For example, the would-be chemical or medical laboratory technician who has the required ability and aptitude but cannot go to college immediately may continue with her science and mathematics courses in high school, adding shorthand and typing to her program by dropping a nonscience subject, or taking commercial training in summer school or following graduation. She can probably obtain stenographic or other clerical work in a chemical or a medical laboratory. If her interest persists and her health is good, she may complete her scientific training at night, aided by her daily contact with scientific workers and, if she has unusual ability, very possibly by a scholarship.

A different type of problem is faced by the young woman upon whose choice there appear to be few limitations. "Not-being-able-to-make-up-one's-mind" is often more confusing than a complicated set of handicaps. In this case, a broad basic training including a course in each of the principal sciences is desirable before specialization. This should of course be supplemented by the many other types of exploratory experiences in school and out. If there is still no significant difference in interest or ability, and there are no limiting circumstances which indicate that the likelihood of satisfying employment is greater in one field than in another, then any one of the fields will be suitable. A "flip-of-the-coin" choice is never a substitute for exploration, but it may well be used to hasten a decision between a number of equally suitable fields. There is a point, which varies with the individual, when specialized preparation should start. To postpone that preparation because of a variety of possibilities is as foolish as not embarking on a holiday trip because there are so many equally attractive places to go.

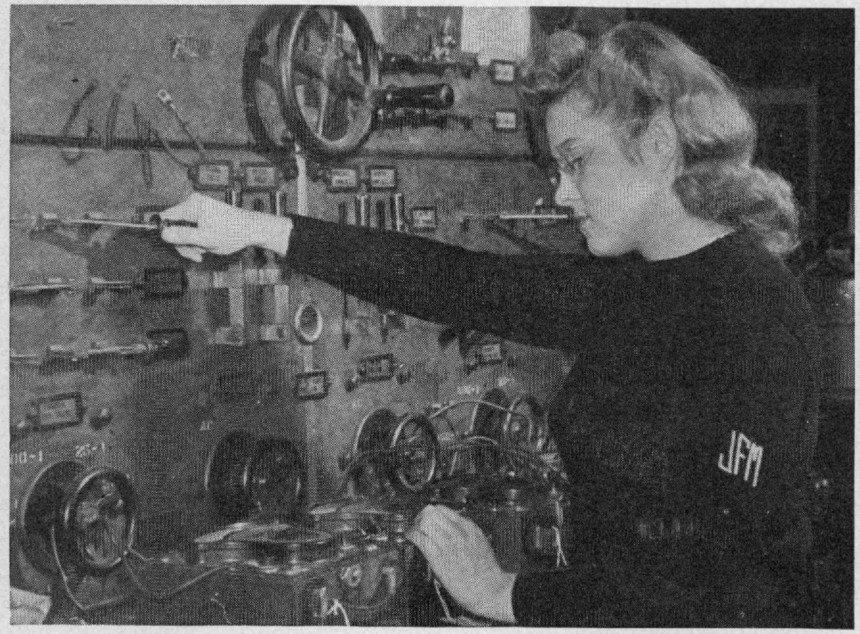
Preparation

Once the choice of scientific field has been made, the problem becomes primarily one of preparation. The omission of an essential tool or working knowledge required for the journey is likely to produce crises later on. The usual minimum training required in the different fields as well as the additional preparation that is desirable have been discussed in the other bulletins in this series and in other sources to which they refer.

One's college should be selected with careful consideration for the work it offers in the scientific field chosen or in the potential fields from which a later choice is to be made. Some 700 of the schools of higher education in the United States grant bachelor's degrees in science (*48*). But there are wide differences in scientific curricula among them. Some offer a wide variety of sciences but few advanced courses. Others offer outstanding training in one science and scant training in another. Some supply a broad undergraduate background looking toward specialization at the graduate level; others provide for specialization at the undergraduate level. There is no magic formula for selecting a suitable school on the basis of size or location or any other factor or combination of factors. The catalogs, supplemented by reports of faculty, graduates, and students, must be studied in relation to one's purpose.

Within each field, the required as well as the desired preparation varies according to the employer. A fairly early decision as to type of work (teaching, research, technical assisting, etc.) and as to type of employer (industrial, Government, educational institution, medical institution, etc.) is helpful in obtaining desirable preparation. For example, the young woman who is interested in the Federal Civil Service should remember that 30 semester hours of science is the usual minimum required for a beginning scientific professional position, and that those with 50 to 60 hours in the sciences are preferred. If industry is one's goal, then it is wise to overcome the usual handicaps of women by acquiring a knowledge of industrial operations, of engineering problems and methods, of mathematics and statistics, of mechanical equipment, language, and tools. For teaching high-school science, it is more important to know how to teach the elements of a variety of sciences and of mathematics and to have the usually required training in the field of education, than to have intensive preparation at the graduate level in one or more sciences. But the latter is desirable in college teaching.

Except in engineering, a doctor's degree is becoming an essential for professional and research appointments in all scientific fields. It is customary to expect faculty assistants and instructors who do not possess the degree to work toward it. Some 90 universities supply



Courtesy University of Cincinnati

Figure 25.—An electrical engineering student explores industrial work on her cooperative job in an electrical manufacturing plant. Here she is working at an instrument board testing transformers.

virtually all the doctorates awarded in science (*48*). Care in planning and in the selection of a school is even more important for postgraduate students than it is for the undergraduate. Mistakes at this scarcity level are more costly in terms of expense to the student and to society.

There are wide variations of viewpoint among educators as to the desirable content and scope of graduate education (*15*). But there is apparent agreement that individualized study in the major field should be integrated with supporting activities. This is especially true in the sciences, where the relationships both within the sciences and with other fields of study are becoming more complex. Although the university can facilitate integration, more depends on clear thinking, planning, and adaptation on the part of the student. Foresighted young women will be rewarded later for their ingenuity in keeping their preparation in line with current needs while basing it on a solid foundation which facilitates later adjustments as they become necessary.

All women planning to work in science would do well to take courses that will make them proficient in technical report writing, in library research methods and the preparation of bibliographies, in the handling and use of laboratory equipment, and in the accurate application of mathematics and statistics to their field of work. Languages—particularly French, German, Spanish, and Russian—are also desirable for those planning to engage in research or in technical library work. The ability to type and to take notes in shorthand is valuable in most laboratory work; it may also be the deciding qualification in obtaining a desired job, in competition with someone otherwise equally qualified.

Obtaining Employment

Working into the kind of scientific work one wants to do is usually a gradual process, not an event that happens miraculously at the end of undergraduate or graduate training. But the first job is important, since it is the vantage point from which future journeys upward or about the realm of science will take place. In some jobs there are distinct handicaps. Only exceptional young women, for example, will find it possible to obtain, or to advance from, jobs which include field work (especially in isolated areas), arduous outdoor assignments in all types of weather, night-shift work, the lifting of large or heavy objects, or other work for which men are ordinarily preferred. On the other hand, it is relatively easy for women to obtain employment requiring painstaking and accurate recording, fine dexterity, writing or abstracting, since many employers say they prefer women for such work.

Courtesy Ohio State University

Figure 26.—A geology student on a field trip in Utah mapping at the plane table while her fellow-students do the rod work and note-taking.

There are also differences in demand and in opportunity in particular types of establishments. The young mathematician may find a job in a small chemical company, but she is more likely to find employment and advancement in a utility or an electrical manufacturing company. Knowledge of where jobs are most numerous in the field of one's interest is a useful guide.

Hurdles

To obtain employment, and certainly to advance in scientific work, women must usually surmount certain hurdles. First, the employer must be convinced of one's value. Then, if one is hired, demonstration through performance is required. Except on the few scientific jobs where women are definitely preferred, a woman is believed by most employers to be a less desirable employee than a man of equivalent experience and training. There are a number of minor reasons given by employers which vary with the type of work and workplace. But the principal reasons are usually stated as follows: A woman is more likely than a man to interrupt her employment because of marriage or home responsibilities. If she stays, the range of her potential usefulness to the organization is believed to be more limited than that of the average male. Some of the reasons for this belief have already been mentioned in the bulletins in this series on engineering and chemistry (Nos. 223-2 and 223-5).

The fact that most employers hold these opinions must be faced by the woman who seeks employment in science, whether or not she agrees with their general validity or in their particular application to herself. Her strategy is to furnish reasonable evidence that she may be an exception to the general rule, or to balance her supposed liabilities with additional assets. To prove that she is an exception, she needs a convincing sincerity and the appearance and manner of a serious, responsible person who acts with consideration for the total effect of her actions.

Her position will be stronger if those who have known her well, especially employers, college professors, deans of women, counselors, and others, can say with conviction, "You can depend on Miss X to take her job obligations seriously. She will never let you down in an emergency. You have my assurance that you will receive full return for your investment in her and that she will be a reliable and valuable member of your staff."

On the other hand, the young woman who has no intention of following a career in science through most of her life should not pretend to be exceptional in this regard. If she does, she not only adds to her own risks in case she should need employment later, but she does irreparable harm to other women. Employers are likely to generalize from the poor record of even one woman in scientific work, where their experience in the employment of women is relatively little. The best course for the woman who intends to work in science only for a limited time is to be frank with herself and with her employer about her intentions: to seek the kind of work in which long service is not expected. Her immediate rather than her potential usefulness should then be emphasized. Offsetting the investment in her training, she can offer additional assets—skill in report-writing, stenographic experience, an unusual combination of scientific training, unusual accuracy on work requiring patience, ability to draft or draw, a special knowledge of the work done in the particular establishment. The value of any one asset to the employer, of course, will vary with the organization with which he is connected. Some prior knowledge should be obtained of the peculiarities of a particular establishment which will guide one in making the selection of employers to whom to apply. This can be gained from published descriptions and directories, or it may be learned from others who work there, or by observation.

Satisfaction and Success

An unusual specialty or an unusual combination of training increases the likelihood for success as well as for initial employment. For example, thorough training in a science and a knowledge of home economics is a combination not likely to be possessed by a man and is valuable in many industries making products for home use. Chemistry, physics, or engineering combined with home economics are

Courtesy U. S. Department of Agriculture

Figure 27.—A chemist, engaged in textile research, preparing to mount a sample of treated cotton fabric for a water repellency test.

especially useful. Some of the related fields in which competition with men for jobs is relatively small, such as technical library work, have been discussed in some detail in Bulletin 223–8.

Although specialties may be counted on to hasten employment or advancement, they are no substitute either for performance on the job or for the attitude toward one's work that distinguishes one who has a "profession." This attitude arises from the humbling knowledge of how much there always is to be learned. It is nurtured by association with others who have worked or are working in the same field, through reading what they have written, listening to what they say, working with them on common problems, and discussing problems and solutions at meetings of professional societies.

Instead of being overwhelmed by the size of the territory she can never hope to explore completely, and struck powerless by indecision, the young woman truly interested in science will make up her mind to do the best and most thorough job she can in a field which she may limit according to her talent, training, and circumstances. A few women, like a few men who may go through life without financial or personal responsibility for the nurture or care of others in their families, may compensate for their lack of contribution to society through their families by devoting an extraordinary amount of time and energy to their scientific work. A few women, like a few men, because of exceptional gifts of health and talent and the cooperation of their families, may pass the benefit of these gifts on to society by unusual contributions to scientific knowledge combined with a normal share of family and civic responsibility. For the average college woman interested in science whose work outside her home is interrupted there remains the challenge of relating her homemaking experiences to her interest in science and of deciding how much of her leisure or hobby time to devote to her scientific interest. An hour a day on exercises or problems planned to retain the skills and knowledge needed in her field is not a complete substitute for part-time or full-time employment, but it may be an insurance against a complete loss of skill.

Whether or not she returns to full-time scientific work ultimately, she will have enjoyed the insurance of retaining employability in her field and will very probably have used her knowledge and her training to some advantage in her homemaking and other capacities. She can aid her own and other children in their initial exploration in the field of science.

Although there is no statistical evidence that most women in science come from families in which they have had unusual opportunity or encouragement in developing their interest, it is not unusual to find a scientist, physician, or engineer in the family of young women who are interested in science. One great obligation and opportunity for women who enter scientific work is to make less difficult the journey of those who come after. This some thousands of women are already doing thorough successful performance on their jobs, thereby establishing a reputation for women for good, solid work. In addition, some who have the gift of writing or speaking or teaching are telling young women what needs to be done in science, what it takes to do it, and how to do it. And all can add their influence to insure that every girl who has the interest and capacity to do so may have full opportunity to explore the realm of science and the chance to plan her life course in that direction.

Madame Curie, who had the humility that characterizes the truly great, has put the goal simply: "We cannot hope to build a better world without improving the individual. Toward this end, each of us must work toward his own highest development, accepting at the same time his share of responsibility in the general life of humanity—our particular duty being to help those to whom we feel we can be most useful" (*8*).

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