Trends in Supply and Demand of Scientific Personnel

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THE PAST 7 YEARS HAVE WITNESSED a great surge of interest in the supply and demand situation among professional personnel. In the previous decade what interest there had been was caused by concern over the effects of the depression upon employment conditions and earnings of professional workers—the wastage and dissipation of skills. The recent interest has had quite the opposite focus: shortages of professional personnel and what can be done to alleviate them.

This change of focus resulted first from such wartime problems as the need to expand research and development work (and other professional work) in industry and in the production programs of the armed forces, and to conserve our limited resources of scientific personnel, particularly with respect to Selective Service. In the postwar period, then, came tremendous new demands upon our scientific personnel for teaching, research, and development, as we achieved unprecedented levels of employment and business activity and a great expansion in enrollment in colleges and universities. Expenditures on research both in industry and by the military establishments of the Federal Government increased over the wartime level.

Finally, the current interest in scientific manpower has been intensified by the world situation. With the research resources of much of Western Europe all but destroyed, it becomes imperative that the United States take leadership in advancing the sciences. Furthermore, to those agencies on whom rests the responsibility for planning the national defense, the insuring of adequate scientific personnel resources in the future is a matter of great moment. Those who are trying to run a research program or a university department are painfully aware of the present shortage of trained workers in nearly every scientific field. The situation hampers scientific work seriously, and I look forward to Mr. Hausrath's discussion of ways

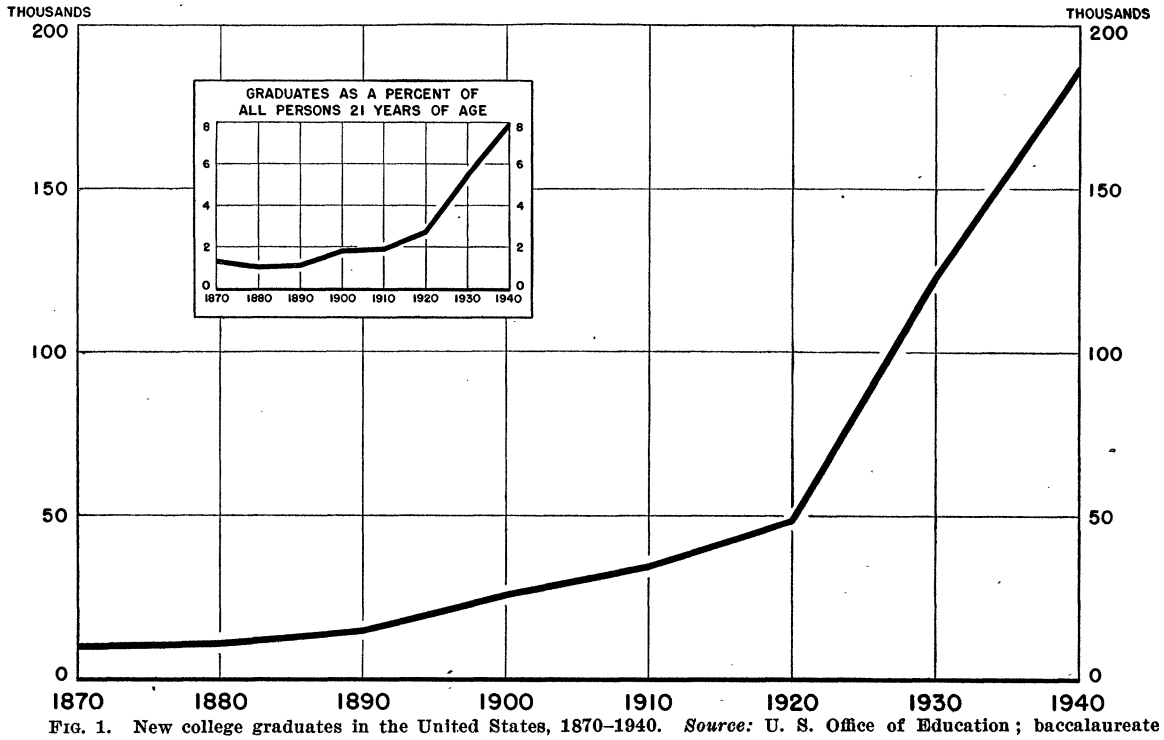

FIG. 1. New college graduates in the United States, 1870–1940. *Source:* U. S. Office of Education; baccalaureate and first professional degrees only.

One of a series of four papers presented in a Symposium on Insuring Adequate Scientific Personnel Resources, held December 30, 1947, during the Chicago Meeting of the AAAS.

of meeting this problem. The question to which I shall address myself is the longer-range trend: What are the prospects that the shortage will be alleviated, that the supply will catch up with the needs?

Trends in Supply

If one generalizes from studies the Bureau of Labor Statistics has made of many occupational fields which reflect widely diverse professions and varying situations, certain broad trends become apparent.

Rising Long-Term Trend in Supply of Scientists

In virtually every professional field and most particularly in the scientific professions, the number of trainees has been steadily rising for the past several decades up to the recent war. This has reflected the increasing proportion of young people going to college. By and large, this trend went steadily forward through the prosperity of the '20s and the depression of the '30s (Fig. 1). It has meant not only steady increases in the number of college students and college

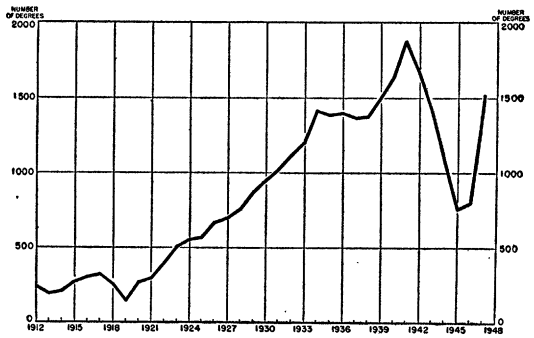

Fig. 2. Ph.D. degrees granted in the natural sciences in the United States, 1912–47. *Sources:* 1912–34, National Research Council; 1934–46, *Doctoral dissertations accepted by American universities,* H. W. Wilson Company, New York; 1947, U. S. Office of Education estimate.

graduates but also a great increase in the numbers of students taking graduate training. This has been reflected in the scientific fields, as shown by Fig. 2.

On the basis of this general trend, the President's Commission on Higher Education has recently estimated that college enrollments in 1960 would be something like twice their level in 1940 (or 2,900,000 as compared to 1,500,000). This Commission, however, has recommended that we strive to provide higher education for as many as 4,600,000 by 1960, or half again as many as would be expected on the basis of past trends.

If a National Science Foundation Bill should be enacted, a further stimulus will be given to the enrollment of students, particularly in the scientific fields, both by the scholarships which may be provided and by the interest which may be aroused by such Federal recognition of the importance of science.

The long-term increase in college enrollments was set back during the war, but has since received new impetus.

Wartime Losses in Training

In nearly every field there was great concern during the war about the impact of selective service upon scientists and potential scientists—the young scientists in industry, teachers in the colleges, and the graduate and undergraduate students. Its effect was most serious in 1945, when the number of Ph.D.s granted in the natural sciences dropped to less than half the 1941 peak (766 as compared to 1882), (Fig. 2). Actually, taking all the years we were at war—1942 to 1945—the number of Ph.D.s granted in science was only 23% less than in the previous 4-year period. The decline in total college graduates with the baccalaureate degree was somewhat greater. The emphasis in college training shifted sharply toward the natural sciences and the medical fields, so that their loss was proportionately less than that of the humanities or the social sciences.

This curtailment of training intensified the wartime shortages arising from increased demand, and its effect is still felt today.

Postwar Increase in College Enrollments

We may expect some relief, however, from the postwar increase in college enrollments. This increase represents, in part, delayed college attendance by veterans, but it is also a continuation of the long-term increase in college attendance. Enrollments are now 2,300,000 as compared to 1,500,000 in 1940. In nearly every field in the sciences, enrollments have reached new highs, and already graduations have surpassed all previous records in a number of fields. This is true, for example, of the number of Ph.D.s awarded in engineering, agriculture, and mathematics.

Moreover, enrollments by field indicate that even greater numbers will be graduating in the next few years. Taking *all* graduate studies together (including sciences and other fields), the number of *doctorate* degrees awarded in the last academic year was reported by the U. S. Office of Education to be 3,787—only 8% higher than the previously recorded peak of 3,537 in 1942. But the number of *master* degrees awarded last year was 35,919, or *one-third* higher than the previous recorded peak (26,731 in 1940). This suggests that we may have a further significant increase in the number of doctorates in the next year or two.

The impending rapid increase in supply of new workers is suggested by figures on training in chemistry—a field in which over half the doctoral degrees

in the physical sciences are granted—compiled by the U. S. Office of Education and the National Research Council. Just before the war 4,000–5,000 bachelor degrees were awarded annually, and a peak of 672 doctorates were awarded in 1941. Nearly half of those in the profession who had graduate degrees had received the doctorate, according to a survey of the Bureau of Labor Statistics. In the academic year ending in 1947 there were 6,009 candidates for graduate degrees, 7,652 seniors, and 9,963 juniors. It would appear that at the baccalaureate level we will soon have twice as many graduates as in the prewar peak year and, at the doctorate level, several times as many. In an occupation of perhaps 80,000 members, with a death and retirement rate of about 1,000 a year for the near future, the new supply in prospect would seem to represent a substantial addition, even though many chemistry students will go on to medical school or to high school teaching. This pattern is repeated in each of the major scientific fields.

Will the present wave of college students subside after a few years? In view of the past trends and the national goals set by the President's Commission on Higher Education it would seem clear that the current peak in college enrollments represents what may be a temporary upward bulge, but this bulge is on a rapidly rising long-term trend. Even if the wave should subside temporarily, a flood will be upon us after a few years. This points to the likelihood that the current shortage will be alleviated in all fields, and eliminated in some, within a few years. It raises the further possibility that in some fields we may even train more workers than we will have jobs for.

In no field has the postwar boom in college enrollment been more striking than in engineering—the largest scientific field of all, with its close to one-third of a million members. The interest of young men in this field, stimulated by the profession's dramatic contributions to winning the war and by widespread reports of shortages of engineers, has brought a deluge of students to engineering colleges. Including engineering students in liberal arts and junior colleges, current enrollments, estimated at close to 300,000, are more than three times the prewar average. In the 1920s about 7,000 men were graduated each year in engineering; in the 1930s, about 10,000; and in the present decade, despite the war, we shall average close to 20,000 graduates a year, hitting a peak of more than 45,000 in 1950 (Fig. 3). Deeply concerned with the implications of these figures, the American Society for Engineering Education has evaluated the potential demand for engineering graduates and has already pointed out the danger of oversupply in some engineering fields within a few years.

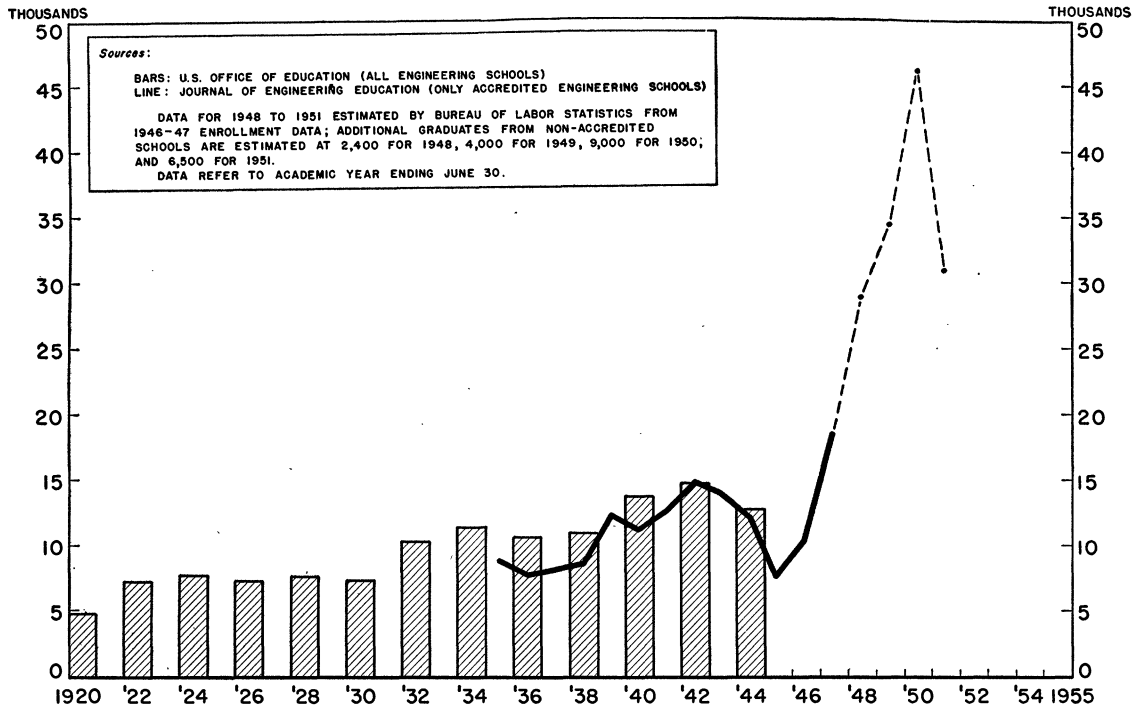

FIG. 3. Engineering graduates in the United States, 1920–51.

Looking at the data on enrollments in many other scientific fields, one may well raise the question: "Is this likely to be repeated in the other sciences?" To answer this question, analysis of the prospective needs for workers in each field and the toll of older scientists which will be taken by death or retirement is required. The experience of the engineers suggests the importance of careful study of the situation in other fields as well.

One thing seems clear from the trends in supply. Taking together the prospective growth in college attendance and the interest in science among young people, there would seem to be no lack of willing and able candidates for scientific professions.

Trends in Demand

The prospects for demand are not as clearly defined. There is no question that the long-term trend in employment of professional personnel, and particularly scientific workers, has been steadily upward. From less than 500,000 at the end of the Civil War the number of professional workers in the country increased to more than 3,000,000 before the recent war and continued to increase during the war (Fig. 4). At the beginning of the period shown,

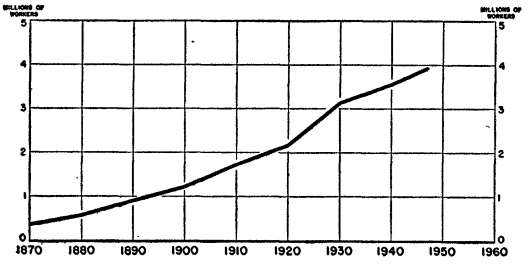

Fig. 4. Growth of professional and semiprofessional occupations, 1870–1947 (gainful workers, 1870–1930; labor force, 1940; civilian labor force, 1947). *Source:* Bureau of the Census; data adjusted by Bureau of Labor Statistics.

three-quarters of the professional persons were employed in four traditional vocations: teaching, the ministry, law, and medicine. Since that time, only teaching has kept pace in its growth with the 10-fold increase in the professions as a whole. Each of the other fields increased by only three or four times, and great new professions, like engineering, chemistry, and other scientific fields in which only a few thousand people were employed at the time of the Civil War, grew tremendously.

Studies the Bureau of Labor Statistics has made of the trends and outlook in most of the larger professional fields indicate that the trend in the growth of the professions should continue; in a recent report prepared for the President's Commission on Higher Education we suggested the possibility of a rise in employment to something like 5,000,000 by 1960 as compared to 3,333,000 in 1940 and just under 4,000,000 in 1947. The likelihood that the expansion foreseen in this study will be achieved—and possibly even exceeded—is increased by the goals the Nation may set for itself in the expansion of science (e.g. the Bush report, *Science, the endless frontier*; the National Science Foundation Bill; and the report of the President's Scientific Research Board, which urged that research expenditures be doubled to $2,000,000,000 a year by 1957), in the expansion of education (such as is recommended in the recent report of the President's Commission on Higher Education), and in the expansion of medical and health research and services. Thus, by and large, there is a great potential increase in the effective demand for professional personnel. The magnitude of the needs in each field can be estimated only after careful study, and even then the estimates are subject to wide error such as would result from such contingencies as, for example, a war or a depression. In the very nature of things, future needs in scientific research are difficult to evaluate. We can sometimes anticipate future demand for a group of skilled workers by observing the invention and introduction of a new machine or process that will affect their work. It is another thing entirely to anticipate the invention itself. The sciences, being at the forefront of the process of technological and economic change, are themselves not too amenable to forecasting.

The experience of the engineering profession suggests, however, that, until both the demand and supply trends are analyzed in each scientific field, we cannot be sure whether we are overtraining or not training enough new people.

We are all concerned that there be an ample supply of personnel to do the scientific work that needs to be done. We are also concerned that we do not encourage more young people to undertake training for scientific fields than the number for whom we can provide jobs. This would not only result in the loss of 4 to 7 precious years of a young man's life, but also would involve the cost to society of educating him. We in the Bureau of Labor Statistics are particularly aware of this problem, because vocational counselors and young people look to us for realistic information on employment prospects.

The training of more scientists than can be employed—if this is what is in prospect (*and we do not now know whether it is*)—would be serious enough if economic conditions should continue to be favorable, though its impact would be mitigated by the fact that it would be relatively easy for those who do not find employment in their chosen field to get

into other types of work. But what if we should have a recession or depression?

Remembering the status of the sciences and professions in the '30s, the low earnings, the wastage of the skills of highly trained people, the frustrations and bitterness that followed, we cannot but be impressed by the importance to scientific professions of the maintenance of generally high employment levels and favorable business conditions.

Implications

Some implications follow from the situation I have suggested—implications for the country as a whole, for the scientific professions, and for those doing vocational guidance work with veterans or young people in schools. In connection with this last group, I am particularly concerned with what we should say to those who are now just thinking of going to college and who would not come out for 5 or 6 years.

(1) *Quality of training.* If there should be a plentiful or overplentiful supply of candidates for scientific jobs, it will, of course, be easiest for those with the best training, the graduate degrees, etc. to obtain jobs. This will accelerate what is clearly observable as a long-term trend toward rising educational standards in the professions—a trend temporarily set back because of wartime shortages. Thus, our advice to the college student may well be to advance as high on the educational ladder as he can. This will be to the benefit of the profession as well as the individual.

(2) *Flexibility.* Because of the possibility that it may not be easy to find employment in some fields, a second point which we have often made in our advice to the individual student is emphasized. Studying occupational trends in many fields, as we do, we have become intensely aware of the uncertainty of economic trends affecting employment and have repeatedly expressed the desirability of maintaining one's occupational flexibility so as to be able to adapt to changing circumstances.

For scientific personnel, this means, in concrete terms, acquiring the broadest possible background in one's field and in related fields and avoiding the tendency to overspecialize. This recommendation, which we make on purely economic grounds, is forcefully reiterated on educational and social grounds in the recent report of the President's Commission on Higher Education.

It has been pointed out that the unemployed and underemployed professionals of the last depression constituted a reserve upon which we were able to draw when we needed to expand our professional employment rapidly during the war. When we count the cost of maintaining such a reserve in terms of personal frustration and the loss to other occupational fields—for example, the skilled trades—of men who might have made a successful adjustment there instead of being castaways on the doorstep of some profession, it seems to me that we cannot think in these terms in the planning of our scientific training program for the future. It is true that a war, if it should come, would require many more scientists than even the highest number we might expect on the basis of peacetime needs. I wonder if we might not seek an answer to this problem in the broadening of scientific education, even on the highest graduate levels, so that we will have an adaptable scientific staff who, with brief courses of intensified training (such as were given in the Engineering, Science, and Management War Training Program), can move from the field of their specialized experience to related fields in a short time. I do not know how feasible this may be and raise the point only as a suggestion for the consideration of this Association.

(3) *Balance among professions.* A third implication suggested by trends in the scientific fields is borne upon us vividly by studies we have made in other professional fields. I am raising the problem of proper balance among the professions.

During the war, college enrollments in the nonscientific fields suffered far more seriously than those in the sciences. This pattern has been repeated in the peak college enrollments of the postwar period. We all know that, with the engineering schools and the scientific faculties overburdened with tremendously increased enrollment, not enough students are preparing for the teaching profession—and this, despite the fact that there is a widely publicized shortage of teachers.

It has become commonplace to say that our advances in the humanities and in the social sciences are so far behind those in the natural sciences that our scientific achievements are placing tremendously destructive weapons into the hands of a society which, in moral, political, and social terms, has not progressed as far beyond the ape man as we sometimes like to think.

I will not labor this point, but will only add that the quantity and quality of teachers in the elementary and secondary schools is necessarily of great concern to the scientific professions. This is certainly underscored by the recent report prepared by the Cooperative Committee on the Teaching of Science and Mathematics, of the American Association for the Advancement of Science, for the use of the President's Scientific Research Board. This report pointed out deficiencies in the teaching of science and mathematics in the elementary and secondary schools which not only make it difficult for the potential scientist

to get a firm foundation in these subjects, but also—and perhaps more significantly—affect the ability of the public in general to think in scientific terms and to understand science. We need to improve teaching in the elementary and secondary schools, and this requires good teachers. The sciences cannot adequately serve their own ends or those of the Nation if too many young people are trained for scientific fields and not enough for other fields.

(4) *Guidance.* All this leads to the conclusion that there is need for the careful selection of candidates for all professions and occupations and careful guidance of all young people early in the educational process. While we cannot dictate to young people the choice of an occupation, we can certainly help them to make the best possible decision consonant with their interests, desires, and aptitudes in the light of the potential supply and demand situation in each occupation. Any help that the scientific professions, through their societies, can give to this endeavor will be a valuable contribution to the country and to the sciences.

Programs for Fuller Utilization of Present Resources of Scientific Personnel

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WORLD WAR II MADE US KEENLY AWARE that America's need for certain resources far outstripped the national supply. Scientific personnel, by common consent, has been proclaimed as one of the most urgent of these shortages.

Enumeration of the present and probable future extent of the over-all shortages of scientific personnel is necessarily far from accurate, based as it is upon assumptions, opinions, piecemeal surveys, replicated counts, extrapolated estimates, fluctuating enrollments, and sheer guesses of future demand. Nevertheless, the unsaturated market for such personnel at present and the prospects for accelerated future demand emphasize the long-range wisdom and present urgency for full utilization of the talents of our human scientific resources.

The last few years have demonstrated the unprecedented returns that can be anticipated from a modest investment in research and development. Those who direct the activities of business and industry, as well as leaders in Federal and private efforts to advance the public welfare and to protect the national security, see clearly the promise of rich returns from the nurture of research. The research rush of 1947 appears to be ushering in a new era of scientific development.

Whether our national supply of scientific talent is numerous or scarce at any particular time, there will always be an insufficient supply of those on whose creative genius the world's progress depends. Full use of their rare talent is a prime responsibility of leaders of scientific activities. This paper reports in brief on some means of contributing to that goal. The thoughts and efforts which will be mentioned are the outgrowth of certain experiences in connection with the work of the Scientific Personnel Division of the Office of Naval Research. This Division was created two years ago—the first of its kind in a government agency—to assist in every appropriate way in improving the climate for research and development in the Naval laboratories, to cooperate with other Federal and private agencies in similar efforts, and to assure the Navy Department that it will be able to carry forward its scientific program with its fair share of an adequate national supply of thoroughly competent scientific personnel.

The research approach of the Division should be mentioned. This function is twofold: first, to see that each program of the Division is based upon as accurate facts as can be obtained by systematic investigation; second, to support research contracts with outside organizations to conduct studies which are basic to long-range planning and management of scientific personnel. For example, it was this Division which initiated by contract the roster activities of the National Research Council. It also initiated a contract with the American Council on Education to make a two-year study of cooperative arrangements with the country's colleges and universities for continuing graduate education for employed scientists.

While such research studies are in progress, the Office of Naval Research and its Scientific Personnel Division have been conducting a number of programs

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