

The Origins of U.S. Scientists

What is the educational background of our doctors of natural science? A survey indicates that liberal arts colleges produce more of them per thousand graduates than large universities do

by H. B. Goodrich, R. H. Knapp and George A. W. Boehm

THE making of a scientist has always been a more or less mysterious affair. The origins of the famous scientists of the past show no particular pattern: some were well educated and some poorly, some trained in science and some untrained, some guided toward science from childhood and some impelled into it fortuitously at a relatively late age. Today science is so complex and formidable a discipline that it might seem there is no room for happenstance or deviation in the development of a scientist; it would almost appear that a candidate must be specially prepared for this esoteric calling from birth, like the Spartans for soldiering. Asked where U. S. scientists come from, the average person would probably say that they flow mainly from the major centers of American intellectual activity and are prepared predominantly in our great universities and special scientific schools.

The facts say otherwise, as a recently completed study makes clear. The survey, a statistical analysis that took some five years, produced several significant surprises. This article will summarize some of our principal findings and conclusions; a detailed report of the survey will shortly be published in book form.

In 1946 a committee of the Wesleyan University science faculty was appointed to study the undergraduate training of U. S. scientists. Supported by the university trustees and subsequently by the Carnegie Foundation, the project rapidly grew in scope. By the time it was completed, it had become a broad survey in cultural anthropology—an examination of the undergraduate ecology of the nation's scientific manpower.

The first step was to define "scientist." For want of a better measure we chose as the subjects of the study all persons

who had received doctorates in the natural sciences and were listed in *American Men of Science*. (We had decided, for various reasons, to exclude social scientists.)

The next step was a statistical survey aimed mainly at finding out just what to investigate. Tabulations from the third (1921) and seventh (1944) editions of *American Men of Science* showed that in each decade from 1880 to 1930, the last year for which complete listings were available, the number of scientists roughly doubled. In certain fields the increase was more spectacular than in others: physics and biology closely followed the general rate of increase; geology, mathematics and astronomy suffered a relative decline in numbers; the course of psychology was somewhat erratic; chemistry, from the turn of the century, rose at an accelerating pace, outstripping the growth rate of any other field. In general, the scientific fields that offered the brightest hope of employment and good pay, especially through the opening of industrial applications, attracted the most people.

The preliminary survey also showed that individual undergraduate institutions varied greatly in their output of future scientists. The output of a given institution of course fluctuated from decade to decade with changes in teaching and administrative staffs, but it became clear that some colleges consistently produced a larger proportion of scientists than others, at least since the First World War. Moreover, these institutions were highly productive not just in one field of science but in various fields.

ACCORDINGLY we decided to study the productiveness of the undergraduate colleges in more detail and to

determine why some turned out relatively many scientists, others very few. As the index of a college's performance in this respect we used the number of graduates per thousand who subsequently earned a Ph.D. in science. In coeducational schools we considered only male graduates, since relatively few women obtain doctorates in science. We also restricted the study to men who graduated from college between 1924 and 1934, in order to obtain a peacetime picture without the dislocations in education caused by the two world wars. As a check on the validity of our use of the listings in *American Men of Science* we computed a test index based on the list of doctorates in the natural sciences compiled by the National Research Council. This index had a high correlation with the one obtained from *American Men of Science*, confirming the validity of the latter.

What does the index show? The first surprise is that small liberal arts colleges are far and away the most productive sources of future scientists among U. S. institutions. Of the 50 leading institutions in this respect (*i.e.*, those that turn out the largest proportion of graduates who become scientists), 39 are small liberal arts colleges (*see next page*). Only three large universities appear on this list of leaders, and only two technological institutions; the others among the 50 are three state agricultural schools and three small universities that lean toward technology.

For some of the smaller institutions on the list the number of graduates and scientists is too small to make the indexes statistically reliable. But the striking accomplishment of the 39 liberal arts colleges as a group is beyond dispute, as rigorous statistical methods demonstrate.

The second striking fact, which may

surprise some, is that the institutions which lead in the production of scientists are mainly concentrated in the Middle West (see map on the opposite page). That this region is particularly productive of scientists is confirmed by a study of all the 500 institutions for which indexes were computed. In that ranking the Middle West and the Pacific coast lead the nation, with the Middle Atlantic States and New England next and the South last.

The significance of this situation is underlined by the fact that in the production of graduates entering some other professions, such as the law, the ranking is quite different. According to a survey made before World War II, the U. S. Northeast is the region most productive of future lawyers; of the 35 undergraduate institutions that led in this respect nearly two-thirds were in New England, New York and Pennsylvania.

OUR next step was to compare groups of institutions, classified according to type, in their output of future scientists. Here the top position was taken by the state-supported agricultural colleges, which as a group had an average index of 19.8 scientists per 1,000 male graduates. The liberal arts colleges came next; the average index of a group made up of 153 privately endowed, non-Catholic colleges graduating from 30 to 200 students a year was 17.8. A group made up of 50 eminent universities stood only in third place, with an average index of 13.8. The leading engineering schools as a group (excluding California Institute of Technology, which occupies a class by itself) produced only 6.4 scientists per 1,000 graduates. The lowest-ranking group was that composed of all the Catholic institutions in the U. S.; their average index was 2.8.

In the case of the agricultural colleges, which achieve top rating here, we must take into account that almost every student in these colleges majors in some kind of scientific work, whereas in the other types of schools on the average only one student in three is a science major. Taking this factor into consideration, it again appears that in proportion to the number of undergraduates studying sciences, the liberal arts colleges are the most productive of scientists.

The low ranking of the technical schools in this hierarchy can be explained by their vocational emphasis; their training is mainly for engineers, not scientists. An engineer receiving a bachelor's or master's degree in a technical school is ready to take a job and does not usually go on to get a Ph.D. On the other hand, a physicist, chemist or mathematician may be severely handicapped in his profession unless he continues his education through the doctoral level.

Probing more deeply by looking into the differences between individual col-

leges and universities, we found some factors which seemed significant. Besides the factor of geographic location, already mentioned, we discovered that the intellectual quality of the student body in a college and the cost of attending the institution were related to the college's production of future scientists. Colleges that had a high average student intellect, as measured by the American Council on Education psychological tests, tended to show a high production of scientists. As for cost of attendance, the relatively inexpensive and the relatively expensive schools were less productive than those of moderate cost. We believe that the failure of high-cost institutions to achieve distinction in the production of scientists is attributable to the fact that the relatively wealthy students who attend them do not, as a class, turn to science. Evidence which we have assembled indicates that scientists are rarely drawn from homes of wealth. The economic prospects of the scientific profession offer too little inducement to wealthy youngsters; they prefer to maintain their economic standing by going into law, medicine, business management or other work with a greater financial reward than science.

THESE were the major findings of our statistical study. Next we got down to cases. Knapp took a year's leave of absence to visit and study at first hand 22 selected liberal arts colleges, some prominent, others obscure. One of the most rewarding investigations was that of Reed College.

This small college in Oregon with a total enrollment of only about 600 has been far and away more productive of future scientists than any other institution in the U. S. Since its founding in 1911, Reed has had a brilliant record of achievement, though from early days it has labored under financial handicaps. Between 1925 and 1940 it produced 12 Rhodes Scholars. During the 1924-1934 period that we studied, 44 per cent of Reed's students majored in a physical or biological science. The college's claim to distinction is not confined to the natural sciences; it is probably as well known for its graduates who have done outstanding work in the social sciences. Though salaries have been relatively low, many top-notch men have come to Reed to teach and have stayed there, disdaining more lucrative positions. Among the students, most of whom commute from nearby Portland, the campus hero is the scholar. The curriculum is organized to foster maximum individuality of instruction, and teachers and pupils alike carry on a tradition of disputatiousness which in many another institution might be a sign of disorganization and dissatisfaction.

Yet anyone who is tempted to draw generalizations from Reed, as far as productivity of scientists is concerned,

should consider Iowa Wesleyan, which stands at the opposite end of the spectrum in almost every way. Iowa Wesleyan, like Reed, has an enviable record in production of scientists. But unlike Reed, it has had little else to recommend it. During the depression it was on the verge of closing its doors, and its regional accreditation was withdrawn for several years. Its student body was of undistinguished quality. Its faculty, which had almost no voice in the administration, was perennially disgruntled and appallingly underpaid; the turnover was so rapid that most of the teachers might almost have been taken for transient guests. The region from which Iowa Wesleyan draws its student body is ground down by an endemic economic depression. But in this setting two men stand out like knights in shining armor. One of them, a competent physics professor and successful inventor, designed equipment for Admiral Byrd's first Antarctic expedition. The other, a chemist, invented a successful process for making patent leather. Consequently to a great many Iowa Wesleyan students a scientifi-

1.	Reed	Ore.
2.	California Institute of Technology	Calif.
3.	Kalamazoo	Mich.
4.	Earlham	Ind.
5.	Oberlin	Ohio
6.	Massachusetts State	Mass.
7.	Hope	Mich.
8.	DePauw University	Ind.
9.	Nebraska Wesleyan University	Neb.
10.	Iowa Wesleyan	Iowa
11.	Antioch	Ohio
12.	Marietta	Ohio
13.	Colorado	Colo.
14.	Cornell	Iowa
15.	Central	Mo.
16.	Chicago, University of	Ill.
17.	Haverford	Pa.
18.	Clark University	Mass.
19.	Johns Hopkins University	Md.
20.	Emporia	Kan.
21.	Pomona	Calif.
22.	Wesleyan University	Conn.
23.	St. Olaf	Minn.
24.	Montana State	Mont.
25.	Utah State Agricultural	Utah
26.	Beloit	Wis.
27.	Bluffton	Ohio
28.	Carleton	Minn.
29.	Charleston	S. C.
30.	Wooster	Ohio
31.	Willamette University	Ore.
32.	Brigham Young University	Utah
33.	Swarthmore	Pa.
34.	Southwestern	Kan.
35.	Lawrence	Wis.
36.	Wabash	Ind.
37.	West Virginia Wesleyan	W. Va.
38.	Rochester, University of	N. Y.
39.	Westminster	Mo.
40.	Simpson	Iowa
41.	Hiram	Ohio
42.	Grinnell	Iowa
43.	Drury	Mo.
44.	Miami University	Ohio
45.	Wisconsin, University of	Wis.
46.	Muskingum	Ohio
47.	Butler University	Ind.
48.	Eureka	Ill.
49.	Lebanon Valley	Pa.
50.	South Dakota School of Mines	S. D.

FIFTY BEST PRODUCERS of natural scientists are listed on the left

ic career seems to hold out great opportunities, and they try to emulate their local heroes.

In addition to investigating individual institutions, we examined the records of approximately 200 professors and attempted to determine what factors, personal and pedagogical, influence students to take up careers in science. This was done by direct investigation and by questionnaires sent to former pupils.

Statistical examination of the ratings assigned by students and by the investigator indicated first that a successful teacher of science usually is not especially distinguished for his mastery of superficial pedagogic skills. Rather, the successful teachers are marked by three cardinal traits: masterfulness, warmth and professional dignity. It would appear that the success of such teachers rests mainly upon their capacity to assume a father role to their students, in the best sense, and to inspire them to an emulation of the teacher's achievements.

In the light of our studies, what environments are most conducive to the production of American men of science?

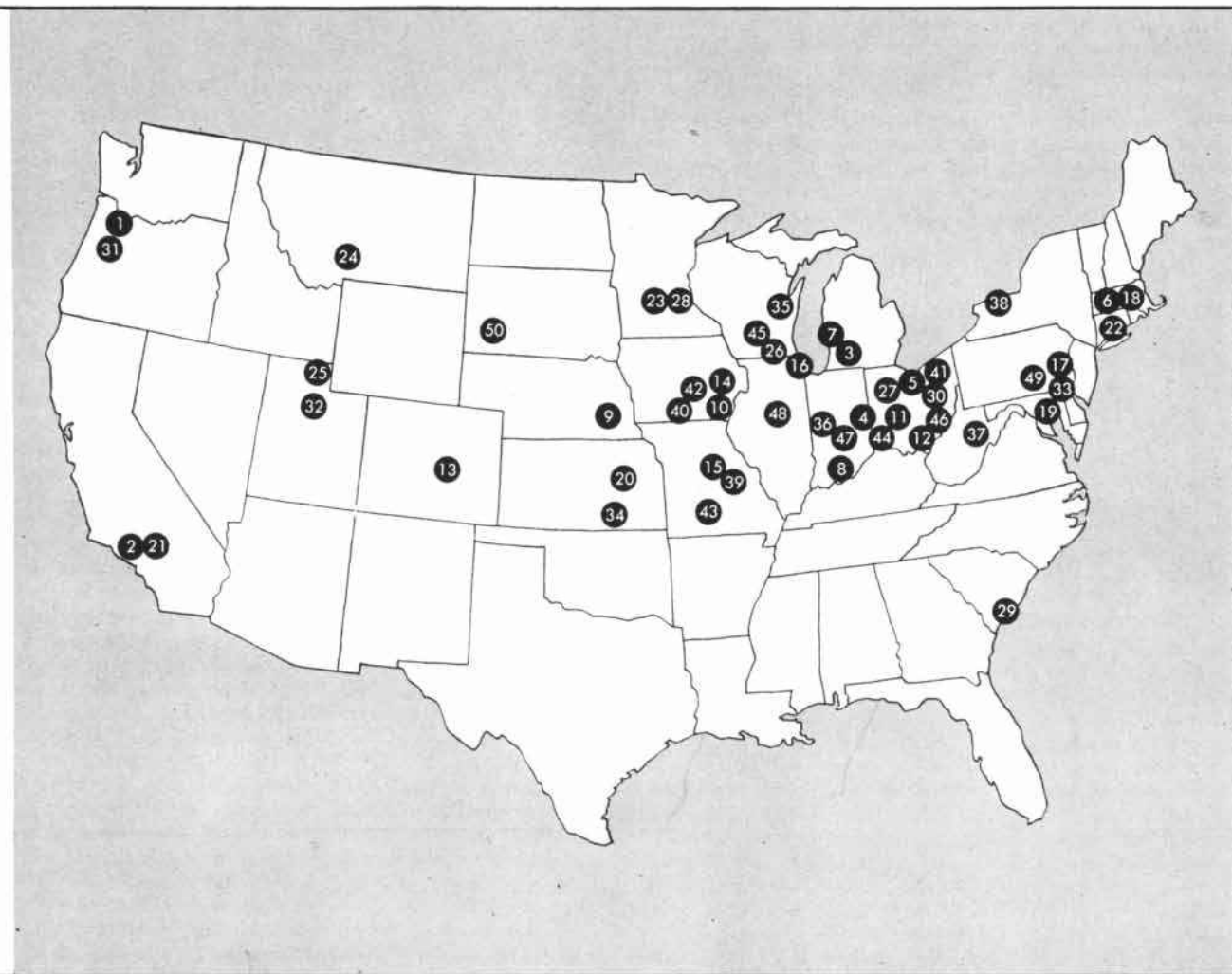
Our evidence points to the fact that the most productive type of institution is a small liberal arts college, especially at a certain stage of its evolution. The typical U. S. liberal arts college was originally founded by a Protestant sect to train clergy and teachers. It drew most of its student body from the surrounding area and the economic middle and lower-middle class. In the second stage it becomes secularized but continues to draw its students mainly from the same population as before. Eventually such a college may develop into a heavily endowed institution of high reputation, attracting a wealthier class of students. But our statistical and case studies show that those liberal arts colleges that are in the second stage of this evolution are most productive of scientists. Among U. S. colleges those in the East and South are generally older than those in the West. Thus many of the Eastern and Southern schools have passed through the highly productive second stage, while the Western colleges are now in the midst of it. Then, too, the frontier traditions of the West, based on intimate association with

the natural universe, seem conducive to the development of scientific interest. One might say that as frontier regions enter the first stages of intellectual development, they turn with particular enthusiasm to the pursuit of science, even though their largely agrarian way of life offers few local prospects of professional employment.

Though some of our conclusions may be tentative and others clearly speculative, our survey has established certain facts that are pertinent to the present manpower emergency. Certainly the clear demonstration of the contributions of smaller liberal arts colleges to the scientific profession should be of considerable interest to those formulating our national policies.

H. B. Goodrich is professor of biology at Wesleyan University and chairman of the Committee on the Education of Scientists. R. H. Knapp is associate professor of psychology at the same institution and director of research for the Committee. George A. W. Boehm is a science writer.

131.8
70.1
66.3
57.5
55.8
55.6
51.1
47.6
47.4
45.5
45.1
45.1
43.9
41.2
39.9
39.9
39.4
39.0
37.3
36.5
36.0
34.3
34.2
33.9
33.4
32.9
31.8
31.6
31.6
31.4
31.2
30.4
30.2
30.1
29.9
29.9
29.8
28.2
28.0
27.6
27.4
27.3
26.5
26.4
26.2
25.7
25.4
25.0
24.7
24.6



side of this illustration. In the third column from the left is the number of graduates per thousand who went

on to take a doctor's degree in a natural science. Each institution is located by a number on the map.