The Origins of American Scientists

Robert H. Knapp and Hubert B. Goodrich
Wesleyan University, Middletown, Connecticut

FOUR YEARS AGO a committee of the Wesleyan science faculty was appointed to investigate some problems germane to the undergraduate training of scientists. This committee, supported by funds from the Carnegie Corporation and the trustees of the university, has in the past three years devoted itself to a study of the undergraduate origins of American scientists and to an examination of the factors that account for the varying achievements of American colleges and universities. The findings of this study are so pertinent to the manpower problems currently under consideration that we wish to present a part of the more extensive report now in preparation.

Obviously, at the outset, it was necessary to evolve some sort of index of the production of scientists which might be computed for the several hundred institutions of the nation whose graduates have continued to full professional status. The index finally evolved was the rate per thousand at which male graduates of the institution between 1924 and 1934 continued to a doctoral level and were listed in the seventh (1944) edition of *American Men of Science*. The index was confined to men only, in order to eliminate any discrimination against coeducational institutions. The time interval was selected in order to avoid, on one hand, the disruptions of the first World War and, on the other, the more recent years for which our data were necessarily inaccurate. Although the statistics reported in this paper deal with the index just described, it is important to indicate that a second index was used, based upon another listing of American scientists compiled by the National Research Council. Correlations between these two indexes proved to be very high, justifying, we believe, our confidence in the validity of our basic index.

We present in Table 1 the first 50 institutions with 30 or more annual graduates, ranked in order of their production index.

The reader will notice that only four universities of eminent reputation appear on this list, that several state colleges devoted to agricultural technology appear, but that the vast majority are small liberal arts colleges, many of obscure reputation. It must, of course, be emphasized that these indexes are subject to substantial error of measurement, and that among the smaller institutions this error is very appreciable. Still, as we shall see, the superior achievement of the liberal arts colleges is sustained even when this factor is taken into account. One may note further that among the first 50 there is a great preponderance from the Middle and Far West. No Southern institutions appear here, and only eight in the New England and Middle Atlantic states. With these significant observations in mind, let us consider the achievements of different classes of institutions.

TABLE 1

Name	Location	P. I.
1. Reed	Ore.	131.8
2. California Institute of Technology	Calif.	70.1
3. Kalamazoo	Mich.	66.3
4. Earlham	Ind.	57.5
5. Oberlin	Ohio	55.8
6. Massachusetts State College (Univ. of Mass.)	Mass.	55.6
7. Hope	Mich.	51.1
8. DePauw University	Ill.	47.6
9. Nebraska Wesleyan University	Neb.	47.4
10. Iowa Wesleyan	Iowa	45.5
11. Antioch	Ohio	45.1
12. Marietta	Ohio	45.1
13. Colorado	Colo.	43.9
14. Cornell	Iowa	41.2
15. Central	Mo.	39.9
16. Chicago, University of	Ill.	39.9
17. Haverford	Pa.	39.4
18. Clark University	Mass.	39.0
19. Johns Hopkins University	Md.	37.3
20. Emporia	Kan.	36.5
21. Pomona	Calif.	36.0
22. Wesleyan University	Conn.	34.3
23. St. Olaf	Minn.	34.2
24. Montana State	Mont.	33.9
25. Utah State Agricultural	Utah	33.4
26. Beloit	Wis.	32.9
27. Bluffton	Ohio	31.8
28. Carleton	Minn.	31.6
29. Charleston	S. C.	31.6
30. Wooster	Ohio	31.4
31. Willamette University	Ore.	31.2
32. Brigham Young University	Utah	30.4
33. Swarthmore	Pa.	30.2
34. Southwestern	Kan.	30.1
35. Lawrence	Wis.	29.9
36. Wabash	Ind.	29.9
37. West Virginia Wesleyan	W. Va.	29.8
38. Rochester, University of	N. Y.	28.2
39. Westminster	Mo.	28.0
40. Simpson	Iowa	27.6
41. Hiram	Ohio	27.4
42. Grinnell	Iowa	27.3
43. Drury	Mo.	26.5
44. Miami University	Ohio	26.4
45. Wisconsin, University of	Wis.	26.2
46. Muskingum	Ohio	25.7
47. Butler University	Ind.	25.4
48. Eureka	Ill.	25.0
49. Lebanon Valley	Pa.	24.7
50. South Dakota School of Mines	S. D.	24.6

In order to make such comparisons, several homogeneous samples were selected. The first, called the college sample, included all institutions graduating from 30 to 200 students annually, privately endowed, not devoted to technological or other specialized training, and not including any Catholic institutions. The second sample comprised 50 eminent universities, all graduating more than 250 annually, all with graduate schools, but not including teachers' colleges, technological schools, or Catholic institutions. Third, we grouped together all Catholic institutions, large and small. Fourth, employing the listing in the *College Blue Book* for 1934, we obtained a sample of engineering institutions. Finally, employing the same source, we obtained a sample of state-supported institutions devoted primarily to agriculture. The average rate of production of each of these samples is given in Table 2:

TABLE 2

Liberal arts colleges	17.8
Universities	13.8
Catholic institutions	2.8
Engineering schools	6.4
Agricultural colleges	19.8

The casual reader may well be impressed with the record of the agricultural schools which, in comparison with the engineering schools, are more than three times as productive on the average. But it should be borne in mind that in both engineering institutions and agricultural colleges virtually all students concentrate in science or in some applied phase of it. Among the universities, liberal arts colleges, and Catholic institutions the figure is only about a third. It will thus be seen that the liberal arts colleges and universities are at least several times more productive than the institutions of technological emphasis, if this correction be allowed. The difference between our selected universities and the 153 institutions constituting our college sample is clearly significant, though the critical reader may question the legitimacy of employing means in comparing the central tendency of skewed distributions. Suffice it to say, by appropriate statistical procedures it may be demonstrated that this ill-selected body of liberal arts colleges is significantly more productive. One may note with considerable interest that, if only those colleges exceeding 60 annual graduates are considered, their average rate of production increases to 19.4. The superiority of these liberal arts colleges is the more impressive when it is pointed out that on the average their cost of attendance is more than $100 a year less than that of the universities.

The next stage of our inquiry was directed to an intensive examination of the two largest samples reported above, namely, the college sample of 153 and the university sample of 50 cases. For the first of these, 19 separate educational indexes were determined for each institution; for the second, 14 such factors. Efforts were then made by various correlation procedures to relate the index of production of scientists in both samples to these independent variables. Two common factors emerged. First, a geographic gradient in the production of scientists was manifest in both samples such that the Middle and Far West occupied the highest position, New England and the Middle Atlantic states middle position, and the South the lowest position. Second, it proved possible to demonstrate a significant relation in both samples between the minimum cost of student attendance and the productiveness of the institution, such that institutions of high and low costs are inferior to those of average costs; in short, a parabolic relation obtains. In addition to these two general findings, it was possible to demonstrate among the universities a significant linear correlation between the ratio of faculty to students and our index. In a subsample of our liberal arts colleges, for which data were available, a significant linear correlation obtained between the median scholastic aptitude of the student body and the production of scientists. All other factors, including entrance requirements, proportion of Ph.D.s on the science faculty, mortality between freshman and senior year, etc., yielded no significant relationship.

Our interpretation of the two factors, geographic location and cost of attendance, which proved to be significantly related to the production of scientists in both samples, should probably be indicated. All attempts to resolve our geographic gradient by reference to other factors were futile, so that it appears to be intelligible only in terms of regional culture and regional vocational dispositions. Yet it is interesting to note in passing that those industrialized regions which offer the greatest vocational future to scientists are not the most productive, whereas the semiagrarian regions of the Middle and Far West produce most abundantly. The parabolic relation between cost of attendance and production of scientists seems best interpreted, especially in the light of our case studies, in the following manner: In institutions of very low costs, the quality of the education offered may be inferior, the student body ill-selected, and the faculty of poor preparation, thus making comparative failure entirely plausible. The inferiority of institutions of high cost, however, must be explained otherwise. Here, with superior selection of students, abundant material resources, faculties of distinction, and other seemingly propitious circumstances, the undistinguished trend seems primarily attributable to the nature of the student clientele. Our evidence indicates that high-cost institutions attract a relatively wealthy clientele who seldom pursue the economically unrewarding vocation of professional science.

Further prosecution of our inquiry involved the case study of 22 selected liberal arts colleges. It is not within the scope of this article to report on this phase of our study, though it may be indicated that this section of our inquiry has occupied the better half of our efforts. Here we have inquired into the characteristic stages of historical evolution of liberal arts colleges, the nature of departmental practices propitious to the development of scientists, the qualities and characteristics of eminent science teachers, and into many aspects of curricular organization and collegiate administration.

The pertinence of our findings to the current scientific manpower problem of the nation needs little elaboration. In brief, they indicate clearly the very large and rather unexpected contributions made by small liberal arts colleges to the training of American scientists, and suggest clearly that the future of the scientific profession would be adversely affected by any policy that neglected their well-being. Scientists, to be sure, can be trained in other types of institutions, but only at a greater cost for a smaller yield.

Technical Papers

Observations on Radioactive Snows at Ann Arbor, Michigan

W. Wayne Meinke

Department of Chemistry,
University of Michigan, Ann Arbor

Rigorous chemical separations performed on radioactivities found in snows around Ann Arbor, Michigan, after the Las Vegas atomic test explosions of January 27–February 6, have definitely established the presence of radioactive rare earth isotopes, barium and/or strontium isotopes, and have shown the possible presence of iodine isotopes.

Samples of snow for the experiments were taken from two sources several miles apart. The most definitive work was done on a snow pack one third to one half of which had fallen prior to January 31, and the remainder of which had fallen during January 31 and February 1. Samples included a complete cross section of the snow pack, as well as separate samples of the top and bottom halves. In all separations new glassware was used, and a "blank" run simultaneously to detect possible radioactive contaminants introduced by reagents, etc. The activities of the snow pack samples listed below are given as of midnight, February 4. Decay of the activities was followed from this date until February 21.

The snow samples were melted, and 10 mg of carriers of lanthanum, barium, and iodine added to 250-ml portions. Chemical separations were based on existing procedures for fission-product separations (*1*). Rare earths (including yttrium) were separated with the lanthanum by hydroxide precipitation followed by fluoride-hydroxide cycles and finally counted as the precipitated oxalate. Activities as high as 100 times background (30 cpm) were obtained in these rare earth fractions. The activity from samples of the cross section of the snow pack corresponded to about 9 dis/min/ml of melted snow, or about 60 dis/min/in.^{2} of snow sampled. These activities varied considerably with the locality of the sampling. From February 4 to February 21 the decay of the rare earth activity could be resolved into two components, one with a halflife of about 2 days, "tailing" into another with a halflife of about 12 days. Aluminum absorption curves of the longer-lived component indicated the presence of β particles of about 0.5 mev and 1.2 mev. Too little activity was available for further absorption data. These halflife and energy values are compatible with those of several of the more prominent rare earth fission products. The decay and absorption data of these rare earth fractions refute the possibility that this activity is due to naturally occurring radioactivities. Of the naturally occurring activities, only actinium would follow through the rare earth chemistry, and actinium isotopes would not show these observed characteristics.

The Ba-Sr fractions were separated by precipitation as the sulfate. These samples showed an activity about 5 times background at the time of separation. Within 4 days this activity increased by about 30%, due, undoubtedly, to the growth of the 40-hr La^{140} daughter of Ba^{140} and also to a small amount of the 65-hr Y^{90} daughter of Sr^{90}. After this initial increase in activity, the samples have decayed with a halflife of about 14 days.

Iodine in the –1 state was separated as the silver iodide. Samples of about half background were obtained, and these decayed with a halflife of about 8 days until accurate counts were no longer possible (about 6 days after separation). It is possible that this activity is due to the 8.0-day I^{131} remaining as a fission product in the –1 state.

The ratio of rare earth atoms to Ba-Sr atoms found in the snow pack corresponds roughly to what would be expected from a fission reaction. Although the distribution of fission products from an atomic explosion is undoubtedly somewhat different from that found in samples of uranium subjected to neutron irradiation in a nuclear reactor (*2*), this difference will probably not be significant (*3*). Hence, because of the chemical distribution of the activities found in the Ann Arbor snows, it can be stated that these activities undoubtedly originated in the Las Vegas atomic test explosions.

Experiments with samples taken from the bottom and the top of the snow pack indicated that the activity was concentrated in the top half of the snow—the portion that had fallen during January 31 and February 1. When portions of this top half were tested it was found that as much as 25 dis/min/ml of rare earth activity was present. Since atomic explosions were set off on the testing range near Las Vegas, Nev., on the mornings of January 27, 28, and