tion of tomato juice bring out the optimum colony development of these two species. In all cases, this medium is as acceptable as whey-galactose agar or digest-galactose agar, and as a rule it is preferable since the colonies of many strains on the tomato agar are decidedly larger and more characteristic than on either of the other media.

2. Incubation in an atmosphere containing approximately 10 per cent. CO_2 is desirable for agar platings of both species.

3. Two hundred to four hundred cc. tomato juice per liter plus 1 per cent. Difco peptone produces the most satisfactory medium.

4. Agar platings of *L. bulgaricus* strains which are very exacting in their growth requirements should be incubated for 72 hours.

No satisfactory explanation can be offered for the growth-stimulating effect of tomato juice upon *L. acidophilus* and *L. bulgaricus* unless it be in the light of an "accessory substance or substances."

Both of these species require carbohydrate for growth. The amount of sugar in tomatoes varies from two to four per cent.; it is made up chiefly of hexoses. Two hundred to four hundred cc. of tomato juice per liter fully satisfy the carbohydrate requirements of these organisms.

However, *L. acidophilus* develops poorly in ordinary nutrient agar containing added hexoses, and many strains of *L. bulgaricus* will not grow at all in such a medium, no matter what sugar is present. There must be some other factor in tomato agar, therefore, in addition to the carbohydrate, which stimulates the growth of these organisms.

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SPECIAL ARTICLES

THE ORIGIN AND DISTRIBUTION OF SCIENTIFIC MEN

THE fourth edition of the Biographical Directory of American Men of Science, which will be published in December, contains an appendix describing the methods that were used to select the scientific men who are designated in the book as those whose contributions to science have been of the greatest value. There were added in the third and fourth editions (1921 and 1927) 601 names to the thousand first selected in 1903 and reselected in 1909. In the book there will be given a statistical study of the origin and distribution of these scientific men, and it may be worth while to print in SCIENCE some of the data.

In the production of the 601 scientific men New York leads with 67, followed by Ohio with 49, Massachusetts with 48, Illinois with 45 and Pennsylvania with 41. The group of states next following consists of Iowa 27, Wisconsin 24, Missouri 21. The position of the North Central States is noteworthy, and is further emphasized by the situation in states having a productivity between 10 and 20, namely, Indiana 18, Connecticut 16, Minnesota 14, Maryland 13, Michigan 13, California 11, Kansas 11. The number of scientific men coming from the South Atlantic, South Central and Western divisions is small, though there has been some gain since 1903.

Of the leading thousand scientific men selected in 1903, Massachusetts produced 134 and Connecticut 40. At the time of their birth Boston was the intellectual center of the country. New York in proportion to its population had then produced about half as many scientific men as Massachusetts and Connecticut, the North Central States about one third as many. The situation had changed for the list of 1910. Reduced to comparable figures the birth rate of leading scientific men per million of population had fallen in Massachusetts from 109 to 85, in Connecticut from 87 to 57. In Michigan it had increased from 37 to 74, in Minnesota from 23 to 59, in Wisconsin from 45 to 54. The intellectual fecundity of the North Central States, as compared with New England, has now further increased, extending westward and southward to Iowa, Missouri and Kansas.

If the 601 scientific men are increased to 1,000 proportionately distributed, which is approximately the result that would have been obtained if 1,000 had been selected, the gains or losses of each state may be found. The situation in New England is ominous for the future. Every state has lost and it appears that the rural population is becoming intellectually sterile. Of the thousand leading scientific men in 1903, Maine had produced 29, of whom 19 ranked in the first 500. Of 601 scientific men mostly born less than 50 years ago, the state has produced six; if a thousand had been selected the most probable number would have been ten. It has consequently lost 19, two thirds of its productivity. Massachusetts has lost 54. Analogous conditions obtain in all the New England States and southward along the Atlantic. The losses of New York, New Jersey and Maryland, in spite of, or it may be because of, their enormous increase in wealth, are startling. Pennsylvania and Delaware remain nearly stationary; there are small gains in most of the South Atlantic and South Central States.

The losses of the eastern states are counter-balanced by the gains of the central states, notably Illinois, Minnesota, Iowa, Missouri, Kansas and Nebraska. All the central states have gained except Michigan,

though the gains in Ohio and Indiana are small. These three are the most eastern of the states and appear to be following in the wake of the Atlantic seaboard. Further to the west there tend to be moderate gains which predict a large future development. So indeed westward does the course of science take its way, but it is not gratifying if the eastern states do not equal the cultural nations of Europe before losing their leadership. This may indicate a waning of the world's great era in science.

Ten of the scientific men on the list of 1921 have died, giving an annual death rate of 4.7 per thousand, which is about normal for men of that age. Of the 591 remaining on the lists of 1921 and 1927, 122 live in New York, 57 in Massachusetts, 52 in Illinois and 47 in California. If the numbers are increased to 1,000 and proportionately distributed, it appears that in comparison with the thousand of 1906 Massachusetts has lost 49, whereas Illinois has gained 24 and California 23. Every New England state, as also New Jersey, Maryland, Virginia and North Carolina, have a smaller proportion of these leading scientific men than they had 21 years ago. New York has gained 11: Pennsylvania has lost two. Next to Illinois and California, Minnesota has the largest gain. The smaller gains or losses in other states show the real situation at the time and are significant, especially in view of the grouping by regions.

When we compare the birth places and residences we find that New York has acquired 55 more of the scientific men than it has produced, the individuals of course not always being the same. Massachusetts has gained 9, Connecticut 4, New Jersey 10 and Maryland 10, these representing men called to the universities. Illinois for the same reason has gained 7, Michigan 5 and Minnesota 4. In the other central states the loss has been large. One hundred and sixty, more than one fourth, of the scientific men were born in them and only 55 reside there. There are but few scientific men born in Washington while many are employed in that city by the government. Of the new group, three were born in the District of Columbia and 76 reside there. Eighty-six of the scientific men were born abroad, so they more than supply the excess in Washington and the balance remains nearly even for the different states.

In 1906 one half (501/1,000) of the leading scientific men of the United States resided in the North Atlantic States and somewhat more than one half (518/993) had been born there. In the short period of 26 years the proportion of those born in these states has fallen to one third (200/598) and the percentage of those residing there to 44.5 per cent. (263/591). The cities of the eastern seaboard depend in large measure on Europe for their population, on the central west for their wealth and for their leaders. They will face a difficult situation when immigration is nearly cut off and centers of wealth and culture develop toward the west. It might be supposed that as wealth increases in the hands of a plutocracy, so scientific and other culture would increase in its centers. There has obviously been no change in native ability in the course of a few years. The only suggestion here made is that the state universities and denominational colleges of the central and western states are more nearly in touch with the people than the privately controlled universities of the east and have proved to be the better agencies for the selection and training of those having ability and ideal interests.

The eastern universities provide education for more men who become leaders in science than the states produce. As American students formerly went to Germany for advanced work, so in a later period they tended to congregate in the endowed universities of the Atlantic seaboard. The first degree of doctor of philosophy in the United States was given by Yale University in 1861, the first scientific man to receive it being Josiah Willard Gibbs in 1863. Prior to 1876, Yale had given 18 doctorates in the sciences, Harvard 4, Columbia and Cornell 2 each. Then was established the Johns Hopkins University, opening a new era of higher education and scientific research in the United States. In the following 20 years the Johns Hopkins conferred 179 doctorates in the sciences and 84 of the recipients (some had died) were on the list of 1,000 scientific men of 1910. During this period Columbia conferred 67 such degrees, Harvard 66, Yale 56, Cornell 33, Pennsylvania 22, Clark (opened in 1888) 21, Chicago (opened in 1892) 8, all other universities 66.[1]

Up to and including 1910, the universities of the United States had conferred 2,513 doctorates for work in the sciences, the distribution being: Johns Hopkins 434, Chicago 276, Yale 271, Columbia 268, Harvard 267, Cornell 222, Pennsylvania 172, Clark 150, all others 453. Thus eight endowed universities awarded more than four fifths of these degrees. In 1926 according to data compiled for the National Research Council by Callie Hull and Clarence J. West there were 740 doctorates conferred in the sciences, the numbers for the leading institutions being: Chicago 78, Wisconsin 53, Johns Hopkins 50, Columbia 49, Illinois 44, Cornell 43, California 38, Yale 38, Har-

[1] These statistics concerning doctorates in the sciences are from an unpublished study. From 1898 to 1915 there was printed each year in SCIENCE an article on doctorates conferred by American universities, including the names of the recipients and the subjects of the theses in the natural and exact sciences.

vard 35, Washington 32, Minnesota 30, Iowa 28, Ohio State 25. Thus Chicago in the central west is far in advance of the eastern privately controlled universities and the seven eastern universities which had conferred prior to 1910 nearly three quarters of all the degrees in 1926 conferred fewer than seven state universities of the north central states and California.

Of the institutions from which the 601 scientific men received their degrees, Harvard with 41 bachelors, 62 doctors of philosophy and three doctors of medicine, stands foremost as it did in 1903. It is, however, now surpassed by Chicago in the number of doctorates, as it was by the Johns Hopkins at the earlier period. After these three universities comes Columbia, followed by Yale, Pennsylvania, Cornell and California. The institutions whose graduates are in the twenties are Michigan, Minnesota, Princeton and the Massachusetts Institute; ranging from 18 to 12 are Wisconsin, Stanford, Indiana, Kansas, Illinois and Ohio State. The privately endowed universities still lead in the number of scientific men for whose education they were responsible usually some twenty to twenty-five years ago. They probably do not do so for the men graduated to-day, but we must wait another twenty years before the figures will be at hand. Many of the 41 bachelors who received degrees from Harvard and the 15 from Columbia and from Yale went to these universities from other institutions after they had planned their careers and the influence of the eastern endowed universities in the creation of scientific men is not large. The private colleges are also losing the influence that they formerly had. In the thousand of 1906 there were 23 graduates of Princeton and of Amherst, 16 of Wesleyan, 14 of Williams, 10 of Dartmouth and of Oberlin. For the contemporary list of 601 men the numbers are: Wesleyan 8, Princeton, Dartmouth and Williams 5, Amherst 4, Oberlin 2.

Another change that can not be regarded as wholly auspicious is the small number of the younger scientific men who have studied at foreign universities. In so far as this means such advance in our own institutions that it is needless to go abroad for special work it is gratifying. But it may result in lesser devotion to the ideals of scholarship and research that had their florescence in the German university of the nineteenth century. Of the thousand of 1906, 117 had studied in Berlin, 84 in Leipzig, 69 in Göttingen, 56 in Heidelberg, and a large proportion had received degrees from these and other German universities. Of the contemporary 601 only one has a degree from Berlin, none from Leipzig. This refers, of course, to men working in the period preceding the war. Perhaps now the various systems of unattached fellowships may lead to a larger international interchange of students. Before graduate students can afford to study abroad, we must, however, find a method by which younger scientific men receive positions in accordance with their ability rather than through the influence of the professors with whom they work.

The majority of scientific men still find their careers in universities. 358.5 (the decimal here and elsewhere referring to a divided position) of the 591 men hold academic positions and in the main earn their salaries by teaching. There are 95 connected with the research institutions that are the most notable development in scientific investigation of the present century. Sixty-two are engaged in industrial work, largely in the research laboratories of the corporations, where their work is not confined to applied science and will doubtless be more and more extended to the fundamental problems whose cultivation and by-products have an economic value far beyond their cost. Such work is besides only a proper return to society for the wealth acquired by monopoly. A public service corporation such as the American Telephone and Telegraph Company, whose profits are limited only by legal regulations, could easily and properly support and give the best facilities to scientific men engaged in research in physics, chemistry, mathematics and psychology. 74.5 of the men are employed by the government. Here again the work is largely but not wholly in applied science, and here again the most beneficial use of money collected by taxation would be the support of research that of all services is the most important for the nation and for the world.

Of these scientific men 60.7 per cent. hold academic positions as compared with 73.8 per cent. of those in the list of 1910. It has been recognized that there has been since the war a movement of scientific men from the universities to the research and industrial laboratories and we have here a measure of its extent. If the numbers are, as above explained, increased to a thousand we find that of this younger group the universities and colleges have lost 133. The research institutions have gained 88.5; the industrial laboratories and applied science 46; the government services 14.5. There is only one who may be classed as an amateur in the present list, as compared with 18 in 1910. We have never had in America a group of men, such as was represented in England by Darwin, Galton, Rayleigh and Huggins, who devoted themselves to scientific work without occupying a scientific position. The specialization of science and democratic institutions have now led to the practical disappearance of those who contribute significantly to the advancement of science without being professionally engaged in scientific or educational work. But we now have men who are professionally engaged in research.

The figures for the separate sciences show that nearly all mathematicians are teachers. Astronomy and pathology are especially well represented in the research institutions, geology and to a lesser extent physics, botany and zoology, in the government work, physics and chemistry in the industrial laboratories and applied science.

In treating the number of scientific men connected with different institutions we are in the main concerned with the present strength of the institutions rather than with changes in distribution, so all the scientific men are included. We have 1,176 instead of 1,000 as in the earlier lists. The competition for inclusion is now, however, more severe, for the list of 1906 included about one fourth of the scientific men of the country, whereas the present list includes only about one twelfth. The figures given are consequently relative. An increase of about 17.6 per cent. means that an institution has remained stationary in its relation to other institutions.

Harvard has on its faculties 89.5 of these leading scientific men and has gained 23 since 1906. Under the existing system of university administration honor should be given to Mr. Eliot and Mr. Lowell for maintaining high academic traditions. In 1906 Harvard had 66.5 of our thousand leading scientific men, Columbia 60, and Chicago 39. Now of 1,176 leading scientific men Harvard has 89.5, Chicago 53.5, and Columbia 46.5. It should also be noticed that Harvard has 21 of the younger men of the group of 250, as compared with 15 at Chicago and 7 at Columbia. Following these three universities are Yale with 42.5 and California and the Johns Hopkins bracketed with 40.5. Cornell, which comes next, has lost relatively. There then follow the three state universities, Michigan, Wisconsin and Illinois, of which Illinois has gained the most. Next come four endowed institutions, Stanford, Pennsylvania, Princeton and the Massachusetts Institute of Technology. Washington (St. Louis) is in the same group and has the largest gain. The only other universities having ten or more of these leading scientific men are Minnesota and the Ohio State. Apart from Columbia the universities that have lost most relatively are Missouri, Wesleyan, Syracuse, New York and Virginia.

The past twenty-six years have witnessed the development of endowed research institutions and the Carnegie Institution of Washington now stands next to Harvard and Chicago in the number of its scientific men of distinction. The Rockefeller Institute, limited to medical research, has also attained a high position. In this period the Carnegie Institution has grown from 7 to 47; the Rockefeller Institute from 3 to 19. The Boyce Thompson Institute, the Wistar Institute and the Mayo Clinic also show gains. The American Museum of Natural History and the New York Botanical Garden, with respectively 13 and 8 of the scientific men, rank before most universities and show a gain since 1906. It is of interest that these institutions can flourish under support and control partly private and partly public.

The industrial laboratories of the corporations, like the endowed institutions for research, have enjoyed a notable growth which is scarcely measured by the 11 men recorded for the General Electric Company, the 10 for the Bell Laboratories and other parts of the Telephone System and the 5 for the Eastman Kodak Company. Industrial research, like advances in engineering, is not always recorded in scientific papers, and is often a cooperative undertaking for which credit is not assigned to individuals. It is, however, to be noted that the number of leading scientific men under these three corporations has greatly increased and of 26 all but three belong to the group consisting mainly of younger scientific men.

The Bureau of Standards has during the period increased the number of leading scientific men in its laboratories from 8 to 23. The Geological Survey, with 28.5, is the strongest group in a single science, but relatively it has lost ground somewhat since 1906, as has also the Department of Agriculture. The Smithsonian Institution, with its government supported subsidiaries, has remained stationary, but this means a moderate relative loss. The U. S. Public Health Service has gained and some states and municipalities are now cooperating in this work.

In the book a table is printed showing the ten strongest departments in each science and their gain or loss since 1906. Harvard shows its leadership not only as a whole but in nearly every department. It stands first among universities in physics, chemistry, geology, botany, zoology, physiology and pathology, second in mathematics, third in astronomy and psychology, fourth in anthropology. There has been a gain since 1906 in every department except anatomy and psychology, though in several cases the gains are due only to the increased number of individuals on the present list. Chicago stands first in mathematics and second in zoology. Columbia stands first in psychology, but does not in any other science have a rank higher than fifth. The U. S. Bureau of Standards leads in physics and the Bureau of Ethnology in anthropology. By a wide margin the Carnegie Institution leads in astronomy, the U. S. Geological Survey in geology, the U. S. Department of Agriculture in botany and the Rockefeller Institute in pathology.

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