of Vermont. Professor Jones is a native of Wisconsin, who did his undergraduate work at Ripon College and later took his bachelor's degree at the University of Michigan. He spent three years in graduate study at Michigan and took his doctor's degree in 1894. After receiving his bachelor's degree he was appointed botanist at the University of Vermont, which position he has held continuously since 1889.

SIR ISAMBARD OWEN, principal of Armstrong College, Newcastle-on-Tyne, has been elected vice-chancellor of the University of Bristol and Professor J. Michell Clarke pro-vice-chancellor.

DISCUSSION AND CORRESPONDENCE

AMERICAN MEN OF SCIENCE AND THE QUESTION OF HEREDITY

TO THE EDITOR OF SCIENCE: The statement of Mr. W. J. Spillman in your issue of February 12 regarding the superiority of country-bred boys, which I contraverted in your issue of April 9 by an appeal to "Who's Who in America," led me to examine the data which Professor Cattell collected for his "Statistical Study of American Men of Science."[1]

I pointed out in my former letter that Professor Cattell found a marked superiority for cities over the rural districts in the production of men of scientific merit, while my own investigation shows that this may be extended to include leadership in various phases of activity.

Professor Cattell, moreover, discusses his data in relation to their bearing on the question of the inheritance of scientific aptitude. I should like in this letter to make a few points of criticism concerning his interpretation of his results. Although he calls attention to the ambiguity and insufficiency of certain of his figures, he nevertheless gives the impression that he considers his results in general an argument against heredity. For instance, he states (page 734) that

> The inequality in the production of scientific men in different parts of the country seems to be a forcible argument against the view of Dr. Galton and Professor Pearson that scientific performance is almost exclusively due to heredity.[2] It is unlikely that there are such differences in family stocks as would lead one part of the country to produce a hundred times as many scientific men as other parts. [This is one of the points I wish to criticize].

Also on page 735 Professor Cattell writes:

> The fact that there is not a significant difference in the average standing of scientific men born in different regions of the country tends to support the conclusion that scientific performance is mainly due to environment rather than to innate aptitude. If the fact that Massachusetts has produced relatively to its population four times as many scientific men as Pennsylvania and fifty times as many as the southern states were due to a superior stock, then we should expect that the average standing of its scientific men would be higher than elsewhere; but this is not the case. [The above sentence expresses the second point that I should like here to criticize.] Like most arguments intended to disentangle the complex factors "nature and nurture," this however is not conclusive. If scientific ability were innate, each tending to reach his level in spite of environment, then a potentially great man of science would become such wherever born, and we might expect a favorable environment to produce mediocre men, but not great men. But this argument is answered by the small number of scientific men from certain regions of the country. Differences in stock can scarcely be great enough to account for this; it seems to be due to circumstance. A further analysis of the curves of distribution might throw light on the problem. Thus it might be that the men of greatest genius were independent of the environment, while men of fair average performance were produced by it. Examples might be given in favor of this view, but I can not see that it is supported by the forms of the curves of distribution. I hope at some time to take up the question from a study of individual cases, but I have not as yet the data at hand. My general impression is that certain aptitudes, as for mathematics and music, are mainly innate, and

[1] SCIENCE, N. S., Vol. XXIV., No. 623, December 7, 1907.

[2] I should like to ask in passing for the exact references to the writings of these gentlemen in which they have stated that *scientific performance* is almost exclusively due to heredity, or words to this effect.

that kinds of character and degrees of ability are mainly innate, but that the direction of the performance is mainly due to circumstances, and that the environment imposes a veto on any performance not congenial to it.

Thus while Professor Cattell certainly is not dogmatic, there are two points which to him indicate that heredity can not be the chief cause of scientific performance. These are, first, the great disproportion in the birth rate of scientific men in some regions as compared with others, and, second, the failure of Massachusetts to have produced men of high average standing.

That one part of the country should produce a hundred times as many scientific men as another, or even fifty times as many, seems extraordinary from any point of view, and perhaps to some it would seem as unlikely from the standpoint of environment as from any other; but the point I wish to bring out is that the more probable significant disproportion lies a great deal lower than this. His figures, on page 733, show that the hundred-to-one ratio applies only where the data are very meager numerically, so that the probable error is necessarily large. In order to increase our totals and decrease our probable error, it is better to average a little belt of the southern states all of which show a very low ratio. Thus we get a close idea of the contrast between Massachusetts and a typical low-ratio southern state. The section comprised of the states North Carolina, South Carolina, Georgia, Tennessee, Alabama, Mississippi, Louisiana and Texas brings in 26 scientific men against 134 from Massachusetts, with an average ratio of 3.75 per million for the south against 108.8 per million for Massachusetts. Thus we find that Massachusetts has produced nearer to twenty-nine times as many, instead of one hundred times, or fifty times as many, which were the ratios mentioned by Professor Cattell.

This is still a wide disproportion and one that undoubtedly means something, but I personally should feel that we were getting closer to its real significance if we nearly double the ratio for all the southern states, on account of the negro population, and make it a question of northern whites against southern whites. By such a method we get a more homogeneous mass of material, a desirability in biometrical work.

According to Professor Cattell "the negro may have a racial disqualification [for scientific achievement], but even this is not proved." It is of course impossible to absolutely disprove such a disqualification, but the same might be said for any organisms, no matter how low in the scale of mental evolution. The fact that millions of negroes have been to school and yet one would scarcely know where to find a single example of a negro scientist suggests strongly an experiment of millions of trials and millions of failures, which gives us some idea of its probability. Is not probability all that we can get out of statistics, anyway? If we adopt the method of leaving the negroes out of the ratios, we find that Massachusetts has produced more probably about seventeen times as many scientific men as a low-ratio southern state. That is, the ratio for the average southern state is raised from 3.75 per million to 6.54 per million, while the ratio for Massachusetts is merely raised from 108.8 to 109.7 per million.

There were 27,001,491 whites in the United States according to the census of 1860, and 1,221,464 of these lived in Massachusetts. Thus this state might have been expected to have produced 4.52 per cent. of the men of science in Professor Cattell's list. As a matter of fact it has produced 15.4 per cent., or 3.4 times the expected.

Now, the interesting question arises—Is this discrepancy more than might be reasonably accounted for by differences in stock? I know of no way of exactly answering this question, but I should like to make record here of some investigations I have carried on which seem to show that the results of Professor Cattell may very likely be entirely due to differences in stock.

First, let us see how Massachusetts stands when general intellectual achievement is taken into consideration instead of special merit in science alone. A little computation from the birth statistics in the latest issue of "Who's Who in America" shows that taking the cen-

sus of 1860 as our basis, Massachusetts has produced 11.6 per cent. of the total, or 2.6 times the expected. This is not as great a disproportion as one finds in Professor Cattell's statistics, but it is a high one. Massachusetts leads all other states, and is easily ten to thirty times ahead of some states. Furthermore, it is almost certain that the standard represented by Professor Cattell's list of one thousand is somewhat higher than that represented by admission into "Who's Who in America." This I assume to be the case because I have calculated that there are about two thousand names of scientific men in the latter volume who would be included under the various specialties tabulated in Professor Cattell's study.

One of the chief reasons which this investigator gives for doubting that his results are due to differences in stock is the fact that Massachusetts has not produced relatively more men of the highest grades in science. His figures are sixty in the total for the superior grades (I.–V.) and seventy-four in the less superior grades (VI.–X.). This would doubtless be a very strong argument in just the direction which he has indicated if it should be substantiated by further statistics; but I have several reasons for thinking that as the figures here stand, this unexpected ratio in the single case of Massachusetts is caused by the smallness of the figures themselves. I have arranged the states in two groups, so that one group, Massachusetts, Colorado, Connecticut, Washington, Nebraska, Kansas, Vermont, New York, Maine and New Hampshire, contains half the total number of scientists, and all the superior ratio states in the order of their superiority. Massachusetts then appears to be an exception, for the group as a whole *does* average more names in the I.–V. grades than in the VI.–X. The difference is, however, only a slight one, being 227 against 205. This is outside of, though not twice, the probable error 7, so the difference is suggestive if not significant, and the total number of cases is at the same time proved not great enough for a final conclusion. If, however, the same ratio were maintained for a greater mass of data, it would soon become significant as showing a higher average standing for scientists born in the high-ratio states. Thus if the totals were all raised a hundredfold, since the probable error would be increased only tenfold, the difference would then be fifteen times the probable error, and the chances against mere hazard's explaining the result would be enormous.

It may be that the actual intellectual differences between those in the I.–V. and those in the VI.–X. grades are really not very great after all. I fancy there are many more names of older men in the I.–V. or higher grades, who with the same amount of brains as many younger men in the lower grades have had a longer time in which to gain a reputation. Even so, the I.–V. grades should average somewhat above the VI.–X., in real ability, though it is easy to see that something of the true difference in actual merit between the two groups is lost as soon as differences in age-average exist between them. Such a force would work mathematically in two opposed directions and cause confusion. Without the age-averages of the two groups, it is impossible to say how this factor might affect the results.

I thought it would be interesting to know if the ratio of scientific men born in Massachusetts would be as high if all examples be taken into the discussion, using the entire book "American Men of Science" instead of the thousand selected and presumably superior group used by Professor Cattell. I have therefore had a count made of the entire number in this book of 4,000 names. There are 436 reported as born in Massachusetts. The exact total number of names is unfortunately not printed in the book, but is given as more than 4,000. Taking the number even as low as 4,000 and assuming that 87 per cent. were born in this country, as is the case with the 1,000 superior ones, the per cent. born in Massachusetts is reduced from 15.4, found for the superior group, to 12.5 for scientists of all degrees of merit. Thus there is something to show that Massachusetts *has* produced relatively more men of science of the superior sort.

Turning now from special aptitude in science to general mental eminence, as shown in

all fields of activity, let us see if there are any facts to indicate that the ratio of 11.6 per cent. for Massachusetts birth, or 2.6 times the expected, found for "Who's Who in America" is any higher if one takes a much more select group of names. I think of only two such lists already in existence. Both possess decided objective value. One is comprised of the names of the thirty Americans included in Profesor Cattell's "Statistical Study of Eminent Men." The other is the roll of thirty-seven in the "Hall of Fame."

I find that out of the thirty in Professor Cattell's list, eleven were born in Massachusetts, or 36.6 per cent. I have gone back to the first census of 1790 as being approximate to the time of their birth, on which basis there should have been about 12 per cent., or the ratio is about three times the expected. In the "Hall of Fame" I find fifteen born in Massachusetts, or 40.6 per cent. against about 12 per cent. expected. It will be observed that both these ratios are higher than the 2.6 times the expected found for the names in "Who's Who in America."

If the greatest eminence is more independent of environment than the lesser forms, why then should not heredity and environment working together produce a higher ratio for Massachusetts when the lesser standard is taken than when only the truly remarkable are concerned? If these illustrious characters are born such and not made, we get some suggestion of how really superior the stock of Massachusetts must be as compared with any other part of the country. It can be seen from the foot-note[3] that with the exception of Virginia the entire country to the south of New York has done almost nothing in producing our greatest Americans. If Massachusetts has given birth to seventeen times as many men of especial scientific merit as some other sections of the country, she has at the same time produced more nearly fifty or a hundred times as many men, if the highest ranks of eminence be alone considered.

There still remains, I think, something from the various figures that I have so far analyzed to indicate that New England, and especially Massachusetts, shows a slightly higher aptitude for science than for general intellectual performance taken as a whole. But is this more than might be expected from differences traceable to selection of stocks, to differences in types of mind in those who emigrated to the various colonies? I can not, of course, answer this question. It is, however, the general impression that the south was peopled, aside from the negroes, by two classes, the gentry and the poor whites. The descendants of the cavaliers were people of refinement and polish, rather inclined to hospitality and good living, with interests of a practical, legal and political sort, than to the serious contemplation which is supposed to have characterized the puritans. As for the poor whites of the south, they are certainly not the stock from which one would expect scientists.

The factor "density of population" which Professor Cattell mentions first under his "main factors in producing scientific and other forms of intellectual performance" deserves, I think, a slight criticism. In the first place we do not find the center for the birth of scientific men (which is around Massachusetts or Connecticut) at all coinciding with the general population center, which in 1860 was twenty miles south of Chillicothe, Ohio. Moreover, a list of the states according to density of population at that time, gives us, District of Columbia, Rhode Island, Massachusetts, Connecticut, New Jersey, New York, Maryland, Pennsylvania, Ohio, Delaware as the ten leading necticut, the proportionate agreement between these two lists, formed by entirely different methods, is almost perfect.

[3] "*Eminent Men*": Massachusetts, 10; Virginia, 7; New York, 3; Ohio, 2; Rhode Island, Maine, New Hampshire, New Jersey, Pennsylvania, Kentucky, Tennessee and Louisiana, each 1; Vermont, Connecticut, Delaware, Maryland, North Carolina, South Carolina and Georgia, none.

"*Hall of Fame*": Massachusetts, 14; Virginia, 6; New York, 4; Connecticut, 3; Rhode Island, 2; Ohio, 2; Maine, New Hampshire, Pennsylvania, Kentucky, Tennessee and Louisiana, each 1; Vermont, Delaware, Maryland, North Carolina, South Carolina and Georgia, none.

It can be seen that, with the exception of Con-

states for density. One finds in this list only three of Professor Cattell's ten leading states. that is, the ten leading states which gave birth to half his total number of scientists. Should the problem be worked out carefully there would be found, I have no doubt, some correlation between the birth of superior men and density of population. Considering the great over-proportion which cities are known to produce, I can not see how it can fail to be so, but it appears on first sight that it will be significant to one who might wish to predict a result, not so much to know that there is a center of density as to know which particular center it is. The group of states, New Jersey, Pennsylvania, Delaware, Maryland and Virginia, are not usually thought of as lacking in "wealth, opportunity, institutions and social traditions," and yet this territory is distinctly behind New England in the production of scientific men, and only as good as the great western and north-central divisions, which were largely peopled by New England stock.

One might ask why the latter districts, if formed from the stock of New England, have not done equally as well as New England itself. The answer from the standpoint of heredity would be that distinguished scientific men come in great proportion from families of the professional and upper classes[4] and that these families had, prior to 1860, generally stayed at home in New England. The great western migration of the last century must have produced a kind of natural selection. Very likely the west has been the gainer and New England the loser, from the standpoint of vigor, energy and ambition. But it seems fair to suppose that while the better of the middle classes might have joined the emigrant trains, the intellectual aristocracy did not.

To distinguish between heredity and environment is at best a difficult problem, and the statistics here analyzed give, of course, no final answer. All I wish to say is, that there is nothing in these birth ratios to shake ones belief in the extreme importance of heredity,[5] or even to show that environment is the main cause of the "direction of the performance" itself.

[4] Conf. Galton, "English Men of Science," London, 1874; Galton and Schuster, "Noteworthy Families," London, 1906; Candolle, "Histoire des sciences et des savants," Genève, 1873; Ellis, "A Study of British Genius," London, 1904.

FREDERICK ADAMS WOODS

BROOKLINE, MASS.,
April 15, 1909

DR. WOODS permits me to add some comments to his discussion. The adjacent states of Massachusetts and Connecticut, with a population of 1,691,213 in 1860, have produced 174 of our thousand leading scientific men, whereas the adjacent states of Georgia, Florida, Alabama, Mississippi and Louisiana, with a population of 3,661,218 in 1860, have produced but seven. The one region has produced per thousand of its population more than fifty times as many scientific men as the other.[1] This great difference, it appears, is more probably due to social conditions, educa-

[1] This disparity will be reduced to nearly half if the negroes are excluded. The fact that the southern whites are nearer to the negroes in their scientific productivity than to New Englanders, is in favor of scientific performance being due to social environment rather than to stock. A similar argument may be drawn from the fact, if it proves to be a fact, that mulattoes resemble blacks more than whites in their scientific productivity. It is, however, also the case that if the southern whites and the negroes were given equally an environment favorable to scientific work, the whites might far surpass the negroes. The question as to whether scientific productivity is mainly due to heredity or environment is not one that can be answered without qualifications and explanations. If environment is the same, differences are due to heredity; if heredity is the same, differences are due to environment. As President Lowell has recently remarked, we have a better chance of rearing eaglets from eagles' eggs placed under a hen than from hens' eggs placed in an eagle's nest. But it is also true that we have a better chance of raising tame eaglets in a chicken coop than in an eyrie. The difference between a man uninterested in science and a scientific man is not that between a chicken and an eagle, but that between an untrained chicken and a trick

[5] For a list of researches which lead to this belief, see SCIENCE, April 9, 1909, page 579.

tional institutions and opportunities for a career than to stock, and is thus evidence in favor of scientific productivity being in the main due to opportunity rather than to heredity. It is probable that if the 174 babies born in New England who became leading scientific men had been exchanged with babies born in the south, the scientific productivity of New England would not in that generation have been materially decreased, nor the scientific productivity of the south have been greatly increased. It is certain that there would not have been 174 leading scientific men from the extreme southern states and only seven from Massachusetts and Connecticut. If the stock of the southern states remains undiluted, it may, as social conditions change, produce even more scientific men per thousand of its population than New England has hitherto produced. Japan had no scientific men a generation ago and China has none now, but it may be that in a few years their contributions to science will rival ours.

The second point discussed by Dr. Woods is my qualified inference that the fact that those regions which have produced more scientific men have not produced men of higher average performance is against the theory that scientific productivity is mainly due to heredity. Dr. Woods says that this would doubtless be a very strong argument if it should be substantiated by further statistics. His discussion of my statistics does not seem to alter the interpretation put on them. He, however, brings forward new data of interest, which show that the scientific men produced by Massachusetts are slightly above the average and that Massachusetts has produced far more than its share of men of unusual eminence. These facts do not, however, affect my argument. It would be expected that the educational advantages and opportunities for research in Massachusetts would give its scientific men a higher average standing than those elsewhere, even though their native ability were the same. It is surprising that this does not show at all in the 1,000 leading men of science and but slightly in the 4,131 included in the "Biographical Directory." In the case of men of exceptional genius, I agree with Dr. Woods that they can not be regarded as the product of their environment. But it may interpose a veto on their performances. There may be "mute inglorious" Emersons in southern churchyards. Lincoln was as great a writer as Emerson; but it is in a way a chance that he made his Gettysburg speech. It is likely, but not proved, that one region of this country or one of its racial stocks has more potential men of genius than another.

While views such as those of Dr. Galton when he says "The impression that all this evidence leaves on the mind is one of some wonder whether nurture can do anything at all" or of Professor Pearson when he says "We inherit our parents' tempers, our parents' conscientiousness, shyness and ability, even [to the same extent] as we inherit their stature, forearm and span," seem to be extreme, I hold, as stated in the paper quoted by Dr. Woods, that "kinds of character and degrees of ability are mainly innate." But I believe also that there is in this country a vast amount of the character and ability required for scientific productivity which is not used for this purpose, and that the quantity, though not the quality, of our scientific work could be increased to almost any extent. What a man can do is prescribed by heredity; what he does is determined by circumstance.

J. McKeen Cattell

cock. Some cockerells can be trained better than others, but there are innumerable cockerells that might be trained and are not.

GENERA WITHOUT SPECIES

The views on genera without species held by Dr. J. A. Allen, as expressed in Science, June 11, 1909, may possibly be shared by a few entomologists interested in restricted groups and by many students of higher forms of life, such as birds and animals. It is not remarkable that an ornithologist or mammalogist, whose entire number of subjects scarcely equals that of the species of a single family of some orders of insects, should hold that personal judgment should enter into the solving of this important problem. It is the man