SCIENCE

VOL. 85 FRIDAY, JUNE 18, 1937 NO. 2216

SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. MCKEEN CATTELL and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00 Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

SCIENCE[1]

By Dr. F. R. MOULTON

PERMANENT SECRETARY OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

A FEW weeks ago I read an interesting article on the enormous increase in the population of the world during the past two or three centuries. In that very brief interval the number of living human beings increased perhaps fivefold. Simply as a biological phenomenon this extraordinary growth in population in the course of fewer than a dozen generations raises interesting questions respecting causes and equally interesting ones respecting consequences.

Of the continents, Europe is by far the most densely populated, with an average of about 130 inhabitants per square mile. Then follows Asia, in which the hordes of India and China give an average of about 60 per square mile. Even in India there are only 177 persons per square mile, or about one third the population density of Great Britain, while China is less densely populated than Illinois. The average population density of North America is about 19 per square mile; in both Africa and South America it is approximately 11 inhabitants per square mile, while in Australia it is only 2.2 persons per square mile.

Several factors have undoubtedly contributed to the recent remarkable increase in world population, but it is probable that the most important of them has been the application of science. This conjecture is supported by the fact that, except in those cases in which migrations have been major factors, populations have shown the greatest increases where the applications of science have been most abundant. It is also supported by the fact that on the whole the densest populations are where science finds its highest development.

In recalling the amazing increase in human population of the globe in the past few generations and in suggesting that the increase is probably due in large

[1] Abbreviated from an address delivered before the Lancaster, Pa., Branch of the American Association for the Advancement of Science.

measure to applications of science, I am not expressing an opinion as to whether the phenomenon has been desirable or undesirable. I have no settled conviction that setting aside "the law of the survival of the fittest" by preserving and protecting the unfit will in the long run prove advantageous to the race. I have no theory that the luxuries, which are enjoyed by those who through science command the materials and forces of nature, are for their good. I simply point out that something startlingly new and extremely important is happening in the world.

It is easy to give striking illustrations of applications of science which have transformed the world. For example, the coal that is burned in the United States each day does more mechanical work than all men in the country do in a year. A ton of freight is carried a mile on the railways at a total cost to the shipper which would buy the time of an unskilled laborer for only a minute or two. A motor car, its materials gathered from all over the world and transformed into precision parts, costs less per pound than to send letters from one town to another. A 60-watt electric light is operated for almost an hour at a cost to the user of the federal tax on just one cigarette. By means in everyday use, a whisper in London can be heard in Chicago. But illustrations of the efficiency of the applications of science always fall far short of making us really understand the miracles that are being performed. One reason is that for countless generations the minds and imaginations of our race have practiced on things within the reach of our unaided hands and eyes. It can not be expected, therefore, that in a generation or two we should have acquired the power to comprehend what science is doing.

Since up to the present science has been concerned largely with material things, both inanimate and animate, we are likely to attempt to measure its importance in terms of physical phenomena. I have spoken of the efficiency of our machines. If I had chosen illustrations from the biological fields, I would have referred to the remarkable results that have been obtained from the breeding of plants and animals and in the curing of disease. Yet in the long run by far the most important consequences of science will be its effects upon our minds. For the moment I am not referring simply to such increases in knowledge as have taken place since our ancient ancestors began their ascent from the level of primitive cave men. I refer rather to revolutions in points of view and habits of mind, such as many times in the history of the world have resulted from causes which were much less important than recent science and its applications. Let me refer to one of them which is distant enough to be seen in fair perspective. When Columbus crossed the Atlantic and Magellan sailed around the earth, the accepted foundations of the physical universe were shaken; when Copernicus and Galileo advanced compelling reasons for believing that the earth is relatively a particle of matter flying in a vast orbit about the sun, those foundations were destroyed. That the revolution in point of view was profound is proven by the fact that it led to bitter controversies for nearly three centuries.

When we consider the bitterness and the length of the controversy over the question of the motions of the earth, we are quite likely to think that it was the most important intellectual revolution that ever has taken place or ever will take place. Such a conclusion is quite unfounded, I think. Certainly the ideas of Copernicus and Galileo had little, if any, direct effects upon the work and the ways of living of the world. They raised no physical burdens from the backs of men. They did not banish the specter of hunger and disease that had always lurked in the shadows of the night. They contained no new reason why a person should love his neighbor as himself. They promised no new paradise for the pure in heart. They simply tumbled man from the proud position he had assumed for himself at the summit of creation.

On the other hand, the doctrine of organic evolution is as important from the practical point of view as it is far-reaching in its philosophical implications. Though it places man in the general stream of life, it provides sound principles for developing the lower forms for his good. Though it chastens him with the story of his humble origin, it points equally to the inspiring heights to which there is a possibility of his ascending. If it were as easy to explore all the vast domain of organic evolution as it is to understand the heliocentric theory of the solar system, the work of Darwin and his successors would already have completely revolutionized our ways of thinking. But the theory of organic evolution involves all the infinite variety of the life of the present, and ties it in with that of the long geologic past. Instead of being not much more than a rather simple geometric diagram, it is a fabric woven from all the strands of life into marvelous patterns which are as yet little understood.

Up to the present I have spoken of science as though it consists of theories which gradually win their way in the minds of men. That tacit assumption may be correct so far as scientists are concerned, but the great mass of human beings are moved by simpler considerations. They respond primarily to physical things—to shelter and food and the comforts of life. Yet the fact that these comforts may be abundantly enjoyed only as a consequence of ten thousand applications of science will gradually transform the point of view of mankind. Perhaps the transformation will not be fully on the level of the conscious mind, but will consist of a

general mass psychology of which there have been many strange examples. If this condition of which I speak shall ever be attained, it will undoubtedly be over a long and winding trail, for the factors at work are many and increasing in number. The goal is, of course, an intellectual and moral world in tune with the uniformities which we know as "the laws of nature." That goal transcends in importance every other objective of science, and scientists will, I hope and believe, give it more and more attention.

In speaking of the ultimate goal of science, I do not, of course, think that scientists should attempt to hitch their wagon only to a very distant and perhaps unattainable star. There are many intermediate objectives worthy of their attention. For example, I think that scientists should very often consider science in the broader aspects of its effects upon human beings. It has sometimes been suggested that scientists should undertake to settle the problems of economics and sociology and government by the methods which they have found effective in the natural sciences. But it is probable that in those strange and wholly different fields workers in the natural sciences would be about as incompetent as politicians would be in a chemical laboratory. It would be unsafe to assume that they are masters of methods that are fundamentally different from those which other intellectually honest men attempt to use in much more difficult fields. It would be even more unsafe to assume that, as compared with men in business and other professions, they are exceptionally altruistic. The only assured fact is that they are introducing revolutionary factors in the world and, therefore, that they should feel a heavy responsibility for examining the results of what they are doing. With deep humility they should cooperate with men in other fields to discover how society may best use the titanic forces which they are placing at its command. They should do this thoughtfully and persistently lest that which so far has on the whole been good should eventually turn out on the whole to be bad.

In certain respects the steep trail science has been traveling in recent decades must soon change to a gentler slope. For example, the number of scientists in the United States has been increasing at a much higher rate than its total population. If the present geometric rate of increase of the names included in "American Men of Science" should continue even for only 150 years, this biographical book would contain sketches of the lives of more scientists than there will probably be persons in the United States at that time. In a comparable period the publication of papers on biology or chemistry would use up the printing capacity of the land. At that time a biologist or a chemist would have to spend several months each year even to glance over an abstract of *Biological* or *Chemical Abstracts*. The biologists and the chemists would have to be in continual convention in a hundred centers in order to present brief digests of their investigations. To operate their electrical equipment physicists would use more energy than all of industry and transportation. Evidently these things would not happen. Science is now in the rapidly growing springtime of its existence. Its roots are in fertile soil and its branches are rapidly pushing out in all directions. Instead of attempting the impossible task of stopping its growth for a period, as England's "gloomy dean" has proposed, it will be better to direct its development so that its fruit shall be good. This is why I am urging that scientists consider carefully the effects of what they are doing.

It is probable that scientists do not generally realize that in an exceptional way they stand upon the shoulders of their predecessors and that for this reason their progress is exceptionally rapid. A scientific principle once established becomes the property of all science; a piece of apparatus once constructed becomes a pattern for later apparatus of the same kind. But not to the same degree is a work of art or a moral principle or even a social order a stepping stone for its successor. For example, there has been more improvement in electric lights in a decade than there has been in literature since the time of Shakespeare. There has been a greater advance in our knowledge of the body of man in this generation than there has been of the moral law since the Sermon on the Mount. Beyond the domain of the natural sciences the complexities are enormous. Never are conditions in the humanities even approximately duplicated. Consequently, there do not exist in those fields the simple laws of the natural sciences. Into this complex, little-understood world, in which the minds and emotions of men are paramount factors, the natural sciences are pouring their amazing products. Although each physical product be simple itself, it may multiply enormously the complexity of the already complex social machine. For example, the automobile has created more interdependencies among our people than existed altogether thirty years ago.

There has often been an aloofness on the part of those who work in the natural sciences from the remainder of the world. Sometimes we have heard boasts that the results of an investigation never could be put to a practical use. Although the richest rewards of scientific research are esthetic, the pure joy of discovery, yet that fact does not justify any touch of snobbery on the part of scientists, for other men may get similar pure enjoyment out of the things they do. No one is qualified to say that what he does is in any way more important, except to himself, than what another one may be doing. There is no good reason for think-

ing that the fields of honest endeavor, however much they may differ otherwise, are on essentially different levels.

In view of the complexities and importance of the humanities, they have been given too little attention. When I make this statement, I am not expressing any approval of immature theories respecting the desirability of more numerous social controls. On the contrary, I think that enforced restraints into standardized patterns will destroy our capacity for improvement. I am thinking, rather, of investigations in psychology, economics, political science, social science and related fields from the objective point of view adopted by biologists, for example. I am thinking, too, of industry as not only depending on many sciences, but as being in a real sense science itself. Science pursued in this broad sense will enrich itself and the world. By its example and its influence it will gradually lead us toward the ideal condition in which every man will be worthy of having his name in "American Men of Science."

Here in Lancaster you have formed a Branch of the American Association for the Advancement of Science. In taking this step you have recognized the great importance of science and have committed yourselves to promoting its interests. I am sure that your meetings are not only profitable to your members but are advantageous to your city. I would that there were a hundred similar branches of the association to carry with high purpose and steady hands the enlightening torch of science. If the whole country were similarly organized the American Association for the Advancement of Science would have more than a million members. Then this great democratic organization would be more nearly fulfilling the dreams of those who founded it and of those who have untiringly devoted their energies to its interests.

Although your meetings here in your own branch are pleasant and profitable, I trust you will not neglect the general meetings of the association. In them you will find rich programs of papers by specialists in nearly every field of natural and social science. You will have the inspiration of contacts with the scientific leaders of the country; and I hope that the association will continually increase the opportunities it offers for meeting and hearing addresses by the eminent scientists of the world. These leaders in the fields of science are the real authors of history. Their work is having more fundamental effects than all the laws which have ever been enacted or all the armies that have ever marched in triumph. The benefits that flow from their achievements are not limited by race or creed or political boundaries or even by time. They offer a perfect example of the fact that "it is more blessed to give than to receive." They provide physical comforts for all men and gradually free their bodies from disease and their minds from the terrors of superstitions. They give to their fellow scientists enchanting new views into the regions which they explore. They prepare for posterity a new world in which to live. I hope the American Association for the Advancement of Science will make a more prominent feature of its programs the appearance of heroes of science. I do not express this hope for the sake of the eminent scientists themselves, but for the benefit of those who serve more humbly in the ranks of science, and particularly for those who look at it from afar through the columns of the daily press. Since men are hero worshippers, it is sound policy to exalt those who are the world's real heroes in a fundamental sense. If this is done honestly and effectively, all of us will realize more fully the importance of what science is doing, and we shall more thoughtfully consider its consequences.

In an earlier geological age certain animals grew so large that their unwieldiness led to their extinction. In our day several fields of science have grown so greatly in numbers of workers and in volume of output that they are becoming seriously unwieldy. Although they are not growing toward a condition that will result in their destruction, the difficulties of arranging for their meetings steadily become more and more serious, and the problem of publishing the results of their investigations more and more nearly impossible of satisfactory solution. Naturally, the American Association for the Advancement of Science, which includes nearly all the natural and social sciences, is confronted with similar difficulties. Indeed, if it undertook to do for all the sciences just what the society for each science does for its own members in the way of providing opportunities for the presentation and publication of highly specialized papers, it would be in danger of bogging down into confusion and ineffectiveness. Instead of narrowly traveling this road, it is giving more and more attention to syntheses of science. In particular fields it encourages symposia by competent authorities. The ideal symposium presents the fundamentals of a domain of science in historical and essential perspective. It is quite possible that the American Association for the Advancement of Science will become the most important agency in the country for promoting and publishing symposia. Its organization gives it the broadest opportunities for such undertakings, and it has unequalled advantages for arranging symposia that reach across the boundary lines of related but usually separated fields. It has an opportunity of being a pioneer in the difficult and undoubtedly extremely important problem of bringing the natural, social and industrial sciences into

mutual understanding and close cooperation for the future of civilization. If the association shall profit by the extraordinary examples of efficiency presented by industry, it will organize its varied and enormous resources in membership to make science in a broad sense the brightest light in the world.

In this local gathering there is something of hominess and comfort which we all enjoy. Here is expressed to an exceptional degree this kindly, unselfish spirit of science. But the meetings of the association as a whole are more like an army on the march. They involve masses and administrative machinery and simultaneous movements on a hundred fronts. Yet they can be so organized that each individual who attends them not only will commune with his fellow specialists, but, through addresses by the heroes of science and by symposia, will be raised to heights from which he can survey the field of operations of the great army of which he is a part. Then, in slightly paraphrased words of Byron, he will say at the close of each meeting of the association:

> I love not Nature less, but Man the more,
> From these our interviews, in which I steal
> From all I may be, or have been before,
> To mingle with the Universe, and feel
> What I can ne'er express, yet can not all conceal.

SCIENTIFIC EVENTS

THE OXFORD UNIVERSITY BUREAU OF ANIMAL POPULATION

THE first annual report of the Oxford University Bureau of Animal Population is summarized by a correspondent of the London *Times*. He states that the inception of the bureau is due to its present director, Charles Elton, whose researches on the regular fluctuations in numbers shown by many wild animals convinced him of the high theoretical and practical importance of the problem of animal population. The bureau was first established in 1932 with the aid of a grant from the New York Zoological Society and with the general approval of the University of Oxford. A trial period convinced the university authorities of the value of the work, and the bureau is now an official institution, with a grant from the university towards its expenses and a fellowship at Corpus for its director. The correspondent writes:

> The range of contacts established by the bureau is remarkable for what is still a small institution. Their main piece of research, on the fluctuations in numbers of voles, is supported by the Royal Society, the Forestry Commission, the Medical Research Council and the Agricultural Research Council, and there has been cooperation with such different bodies as the Scottish Meteorological Office and the London Zoo. The research on partridge numbers is chiefly financed by Imperial Chemical Industries, with aid from private estate owners throughout the country. A remarkable example of cooperative research is that on the fluctuation of the snowshoe rabbit in the North American continent. For this reports are analyzed from nearly 700 separate observers, from the Hudson's Bay Company, the Canadian National Parks Service, a paper corporation in Anticosti, the Alaska Game Commission, the Newfoundland Department of Natural Resources and the United States Bureau of Biological Survey.
>
> Results of this and related inquiries have made it possible to build up a picture of fluctuations in Canadian wildlife for over 100 years. The period of the fluctuation was originally supposed to be determined by the 11-year sun-spot cycle, but the more accurate records now available show that this can not be. The period averages a little less than 10 years, and must be determined by some hitherto undiscovered climatic cycle. That this is likely to be so is shown by the research on vole plagues. The numbers of voles, it was found, fluctuate with a three- to four-year periodicity. Quite recently the superintendent of the Scottish Meteorological Office has discovered a rhythm in factors affecting storminess, which exhibits an identical rhythm that unquestionably (though by what precise means is still unknown) causes the voles' fluctuations. Thus for certain purposes animal numbers may constitute a new type of meteorological instrument, serving to detect hitherto unsuspected weather-cycles.

A side-line undertaken by the bureau is the investigation of the fluctuation in numbers of the semi-wild exotic animals which have been liberated in Whipsnade. The researches of the bureau have great practical importance. If adequate records are available scarcity due to persistent over-destruction can be readily distinguished from the purely temporary scarcity due to a "crash" in a normal cycle of fluctuation. Among the fur-bearing carnivores of Canada, for instance, the lynx and fox show normal cycles; but the marten has been over-trapped and now is no longer able to increase rapidly in numbers at regular intervals as it used to do.

THE MARIA MOORS CABOT FOUNDATION FOR BOTANICAL RESEARCH

THE establishment of the Maria Moors Cabot Foundation for Botanical Research is announced by Harvard University. The initial endowment is $615,773, provided by Dr. Godfrey L. Cabot, of Boston, a graduate of Harvard College in the class of 1882. The income from this fund is to be used for the first fifty years for plant research, all restrictions being removed after this period. The purpose of the gift is to investigate methods of increasing the rate of growth of plants, especially trees, and consequently the rate at