SCIENCE

VOL. LVIII OCTOBER 19, 1923 No. 1503

CONTENTS

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

THE SCIENCE PRESS

Lancaster, Pa. Garrison, N. Y.
New York City: Grand Central Terminal.

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.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

SCIENCE AND SOCIETY

I PROPOSE to-day to compare very briefly the problems of the college graduate of my own time thirty-two years ago and those of the present, and then to point out what seems to me to be the most vital elements which must enter into the solution of the problems which to-day's graduating class will be called upon to face.

I have a very vivid picture of one of America's most constructive statesmen, Senator John Sherman, addressing my own class upon its graduation, and wishing with all his soul that he might be in our shoes.

My generation, said he (and his constructive work covered the fifty years from 1845 to 1895), has had for its great task the preservation of the Union, the assuring to posterity of one unified representative government extending over the whole vast area embraced within the limits of our states and territories, the problem—new in the world's history—of creating the conditions which make it possible to try out democracy on a huge scale. That problem we have solved at an awful expense of money and of human lives. The war for the preservation of the Union is passed, and the process of recovery and reconstruction has been in the main completed. Your problem, young graduates, is to show how well, during the next half-century, you can make that kind of government work in a country three thousand miles one way by two thousand the other.

The half-century since 1891 is now two thirds past, and, if it were fair to shut our eyes to the rest of the world and to take the present situation in the United States as an index of how well we have carried out that task, my generation in America might perhaps look back with a certain complacency upon what it has done so far. Certainly, gauged by the standard of the material prosperity of the average citizen alone, I suppose that it will be generally agreed that in this June, 1923, the United States finds itself better off than any country has ever been at any time in the world's history—considerably better off than it itself was in 1891. Wages have more than doubled since that year, and costs have not yet doubled. The condition of the man at the bottom, whether you consider that man to be the unskilled laborer or the young Ph.D. seeking a job, is better now than it was then, and it is probably immensely better than it has ever been in any preceding period of the world's history. In 1896, after a four-year college course, three years

[1] An address delivered at the Commencement of Stanford University, June 18, 1923.

of work for the Ph.D. degree, and a further year in Germany, I myself obtained a position in physics in the University of Chicago at $800. To-day, under the same circumstances, I might hope to receive from $1,800 to $3,000.

Our intellectual and cultural life has made much progress, too. In 1891 there was very little science in the United States. My friends called me very uncomplimentary names for going in for physics—"The deadest imaginable of subjects." They themselves were going in for that fascinating and at that time new subject of sociology. Since that time the advances in that same dead physics may be said, without a display of too much enthusiasm, to have thrilled the world, while the successes of sociology are more problematical. Physics has opened the eyes of mankind so that it can now see in very truth new worlds—a marvelous world of electrons, already quite well explored, which underlies our former world of atoms and molecules, a world of quanta, not yet well understood, which lies perhaps beyond the ether. And our own country, too, has had a reasonable share in this progress. Also the possibilities that can be seen ahead for further advance, both in knowledge and in physical well being are exceedingly alluring if only stable conditions of society can be maintained so that science can have the opportunity to work out these possibilities.

This amazing progress in science has been reflected in industry too. Since 1891 has come the internal combustion engine which now gives the humblest laborer a car (California has one car for every four and a half inhabitants), the "movie" giving him inexpensive, though as yet perhaps not always wholesome, recreation, the amplifier and the wireless, furnishing the world with a huge nervous system which transmits intelligence practically instantaneously throughout its whole giant frame, the airplane, in which man outsoars the eagle and outspeeds the swift, the X-ray with which he discovers the hidden sources of disease in his body, and antitoxines and antiseptics with which he has already banished forever certain of mankind's most awful plagues.

The discoveries which I myself have seen since my graduation transcend, I think, in both number and in fundamental importance all those which the preceding two hundred years brought forth, and these latter far transcend all those of the preceding five thousand years. Such is the acceleration at which the processes of evolution in human affairs are now going on,—a fact tremendously stimulating or terribly depressing according as one has great faith in man or little.

All these things might have been included in the vision which John Sherman had when he longed to be in our shoes so as to help work out the problems which he saw ahead in a land at peace, prospering under stable republican government and working out its own destiny for the enlightenment, and later, perhaps, for the emulation of other nations not yet free from the domination of Caesars. But what Sherman did not see was that through a vastly more bloody and desperate war than any which his generation had known or even dreamed of, not alone we, the inhabitants of the United States, should be faced in 1923 with the problem of making democracy work on a huge scale, but with us almost every important nation on earth. This problem has now become not merely a national but a world problem—and that, too, before the world was ready for it.

But we can not now go back. The increase in the efficiency of the instruments of destruction has for fifty years been making it harder and harder for any autocrat or oligarchy which gets into control of the machinery of government to be dislodged. Revolution against tyranny can not occur in the future as easily as in the past. Russia to-day, under as fateful a despotism as ever existed anywhere, is a living proof of the disasters which may come to a country which loses self-government, which lets any privileged class whatever, whether represented by a so-called communist like Trotsky, or a "God-ordained" kaiser like Wilhelm II entrench itself in power. With revolution, then, increasingly difficult because of the growth and application of modern science I can see no hope of progress save as society adopts a form of government which permits of progress by *evolution* instead of by revolution, which makes possible the peaceful and gradual replacement of men and policies by new men and new policies when rulers lose their sense of proportion, as men in power are likely to do, and when policies have ceased to be productive of social results. *One of the greatest contributions of science to life is the discovery that progress is in general made by the evolutionary process.* Einstein does not replace Newton; he merely supplements him. *There are no revolutions in science.* In so far as Newtonian mechanics was a body of experimental facts it is eternally true. The whole of Newton is incorporated in Einstein. *Let the revolutionary reformer ponder well that fact.*

The supreme question which the present generation faces is, then, can we make democracy work, not merely for America, but for the world? *Can we replace bullets by ballots?* That question is being asked more searchingly and more fearfully to-day than it was in 1891. The answer to it is to be given in the main by you, young graduates, and by others of like opportunity. *If an affirmative answer is found at all it will be, as I think, because the nations of the earth, including our own, learn to take a more rational, a more objective, a more scientific attitude toward life and all its problems than any of them*

have as yet learned to take. Some wag has said that the anti-evolutionist is opposed to evolution because it never did very much for him. I wish to take that witticism altogether seriously. It is literally true that a good many individuals are still *in the jungle* so far as their method of meeting life's problems, so far as the mainsprings of their conduct are concerned.

For in the jungle ignorance and prejudice and impulse and emotion *must* determine conduct, and *so long as that is the case none other save the law of the jungle is possible.* Man himself is just now emerging from the jungle. It was only a few hundred years ago that he began to try to use the experimental and the objective method, to try to set aside all his prejudices and his preconceptions, to suspend his judgment until he had all the facts before him, to spare no pains to first see all sides of the situation and then to let his reason and his intelligence, instead of his passion and his prejudice, control his decisions. That is called the scientific method. Why? Not because it is applied only in the study of science, but because it has had its most striking development in the sciences, and because it finds its finest application to-day, though not its only one, in the analytical subjects of mathematics, physics, and chemistry. It is because of that method that these sciences have very recently made the astounding strides referred to a moment ago. It is because of it and what it has done already that scientists dare to hope that the law of the jungle can ultimately be displaced by the law of reason, not only in our domestic affairs but in our international ones as well. It is because of it that scientists in general believe that human life may be indefinitely enriched and human happiness enormously multiplied.

But how far are we from the application of that method now, even in our so-called enlightened United States? Let a few illustrations answer. A few weeks ago the daily press reported that the New York legislature had passed a bill requiring that the history of the revolutionary period be taught in the New York schools so as to develop patriotism. The only possible interpretation of that act was that the legislature desired the facts of the revolution to be distorted to suit the prejudices of dwellers in New York. It is fortunate, indeed, that this was the same legislature that has just passed a bill which, whatever its purely legal and technical status, is yet deliberately *aimed at* the nullification within New York State of the present constitution of the United States, since otherwise there would be two such legislatures instead of only one in this country. And yet New York thinks that it is representative at least of the average state of evolution and of intelligence of the country. Let us hope that it is mistaken!

My second illustration, however, is not taken from New York. I recently asked a prominent school book publisher if it would be possible to begin a slow process of eliminating the misunderstandings which lead to war between peoples by inducing publishers of school histories in all countries to submit their proposed school books to three or four international historians of world repute, who would endorse them, if they were able to do so, by the statement that these histories pictured essentially correctly the portions of the field of history with which they dealt. His reply was, "No. It is not yet possible to take such a step in the United States, for the reason that school boards do not yet in this country want history to be taught as it happened. They want something to be called history which pleases their pride and appeals to their prejudices, and I know it because we are ourselves just having our histories attacked in the State of Washington on the ground not that they are incorrect but that they are unpatriotic. And this sort of thing is happening to publishers all over the United States." This means that we are doing in our America to-day precisely what the whole world condemned Germany for doing in all the years preceding 1914, namely, *teaching nationalism in preference to truth.*

The American newspaper which claims to have the largest circulation of any newspaper in the world displays as its motto the words of Stephen Decatur completely inexcusable, at least as they are usually understood, "Our country! May she always be right, but our country right or wrong." It was in very fact the international hates and misunderstandings caused by just that sort of teaching which brought on the great war. And yet there are a dozen American newspapers which are sedulously spreading not merely anti-British but anti-international propaganda of every description.

A British visitor who has traveled and lived in this country recently told me that if his analysis were correct the United States was more likely to start another war than was any nation of Europe. But if another such war as the last is started, I, for one, fear that the world may bid good-by to civilization. I am far from being a pessimist, but the history of central Asia, once at the center of the earth's civilization, and again, the very recent history of Russia, both show that it is possible to destroy civilization completely in a very few years of time. *Let those who deliberately set to work by distortion and untruth, by misrepresentation and cynical mistrust of motives, to stir up class hates and class prejudices in America, reflect well upon these things.* Some of them do it from base motives, because the mob has votes or pennies; others have good enough intentions but neither the intelligence nor the training to catch the scientific spirit and to be able, or even to try, to distinguish truth from falsehood. Well meaning men without poise or any sort of scientific discrimination, and highly trained

and able men without conscience are about equally grave dangers to the wholesome development of human society.

Another glaring example. Look at the storm of protest raised in the United States Senate when Mr. Harding proposed that we begin to try to establish a machinery for settling judicially our international difficulties by joining the Hague court of international justice, a body organized largely through the genius of our own Mr. Elihu Root, and then ask yourself whether that protest was dictated by ignorance and prejudice or by intelligence and the scientific spirit.

But we do not need to go to Washington, to Chicago, or to New York, nor even to the field of politics for all our illustrations. We have, indeed, not yet passed anti-evolution laws in California, but we have many people even here who hasten to condemn evolution without having the remotest conception of what it is that they are condemning, nor the slightest interest in an objective study *of the evidence in the case which is all that "the teaching of evolution" means,* men whose decisions have been formed, as are all decisions in the jungle, by instinct, by impulse, by inherited loves and hates, instead of by reason. Such people may be amiable and lovable, just as is any house dog, but they are a menace to democracy and to civilization because ignorance and the designing men who fatten upon it control their votes and their influence. The churches are often charged by their critics with having more than their share of this type of jungle dwellers, but my own observation is that there are almost as many within the churches who have caught the scientific spirit as there are among the so-called scientists themselves, and many more who have caught what is even more essential to progress, the altruistic spirit. Medical science certainly is full of the jungle dwellers, as is shown by the existence of such a scientific anomaly as sects in medicine. *For science is an objective study of the facts of nature.* It uses any and all hypotheses which assist in correlating these facts, and its many hypotheses have had varying degrees of success in making such correlations, but science never commits itself as a matter of faith to any of them, not even to evolution. When it does so it ceases to be science.

But what, now, is the remedy? Is there any hope for the improvement of the situation and the elimination of the dangers which threaten the permanence and success of our modern society inside our commonwealth and outside of it? I have no nostrums to propose. The longer one lives the less confidence does he have in any universal formula. The situation itself which I have portrayed suggests the only solution which there can be, namely, the slow growth of a larger degree of *both public intelligence and public conscience than we now have. Intelligence enables one to know better what he ought to do, while conscience keeps him doing as he knows he ought.* In America the school has concerned itself primarily with the first field, the church with the second. Which will play the larger rôle in getting us out of the jungle I will not attempt to say, but it appears to me fairly obvious that without both of them human society is headed for the rocks. But science, imbued with the spirit of service, which is the essence of religion, and religion guided by the intelligence, the intellectual honesty, the objectiveness, and the effectiveness which is characteristic of the spirit of science, can between them, without a shadow of a doubt, in view of the rate at which discoveries are now being made and at which changes are being brought about, transform this world in a generation. If that transformation actually gets very far in your lifetime, members of the class of 1923, it will be because of the following sorts of influences:

First, it will be because you graduates, and others of your opportunities, act as centers for the growth in the communities in which you live of both the scientific spirit and the altruistic spirit, and a relatively few such centers can accomplish wonders, for most men follow while but few men lead. It will be because you do not sit idly and thoughtlessly by expecting that leadership to come from New York or Chicago or other great centers of population. Remember that Athens, with its hundred thousand Greeks, did more to shape the development of the race than any city of fifty times its population has ever done, and that an insignificant village in Galilee did more than Athens. The only way in which public sentiment, the sovereign power in a democracy, can be developed is by having hundreds and thousands of such centers as you may yourselves create in the communities in which you live. There is nothing new nor spectacular about that remedy any more than there is about any of the processes of growth, but these are, after all, the processes by which most of the progress of this world comes about.

Secondly, I think that you or some one else, will soon take steps to so reorganize the teaching of science in the public schools as to give a larger fraction of the pupils who go through our high schools and colleges more training, particularly in the mathematical and physical sciences, for from my point of view there is no training in objective, analytical thinking, nor in honesty and soundness of judgment, which is comparable to the training furnished by these sciences. I know of no training for life which is equal to it, whether one is to be an engineer, lawyer, business man, or preacher. It is an exceedingly wholesome thing to work at some time in one's life in a field in which *the distinction between right and wrong, be-*

tween loose and correct thinking, can not be obliterated or escaped; to learn that there are eternal physical laws and presumably also eternal esthetic, moral, and social laws in conformity with which one must proceed if he is to arrive at correct results; to learn, too, that four fifths of all the experiments which we make in our physical laboratories in the hope of developing new relations, establishing new laws, or opening up new avenues of progress, are found to be directed along wrong lines and have to be abandoned. There is no reason to suppose that any larger percentage of the efforts which are made toward social, political, or educational reforms are in the actual direction of progress. With a better realization of these facts we should have less worship of the new *merely because it is new,* fewer cubists in art, in literature, in education, in politics, in social reform. One of the well-known residents of Southern California who had a fine training in physics and mathematics but has spent his later life as a farmer and fruit grower said to me the other day, "I do not use my science much on my ranch. I guess and blindly follow tradition almost as much as my neighbors, but I know *when I don't know* and they do not. That is worth all my education cost me." If such a change in our public school curriculum as I am suggesting is brought about at all, it is going to be done, I think, through a reorganization of the required group of studies rather than by important changes in methods of instruction in the individual sciences. This is primarily a matter of the public schools.

In the third place, public spirited men are going to see more and more that the support in a large way of scientific research is an investment which brings the largest returns of satisfaction to themselves and of progress to mankind which can be made at all. It is my own belief that no efforts toward social readjustments or toward the redistribution of wealth, such as so many well meaning people are urging in a thousand different ways, have one tenth part as good a chance of contributing to human well being as have the efforts of the physicists, the chemists, the biologists, and the engineers toward the better understanding and the better control of nature. The distribution of wealth can, of course, be improved, and I welcome every constructive and sane effort toward its improvement, but the results which can be accomplished for the well being of mankind by efforts in this direction seem to me to be utterly trivial in comparison with those which may be brought about by physical and biological research. An eminent and progressive economist told me lately that no sort of redistribution of the wealth now available could possibly add more than ten per cent. to the income of the average man, and probably much less than that. To replace for the toiler a dollar meal by a dollar and ten cent meal is scarcely my idea of the millennium.

In the fourth place—and this is in my opinion most important of all—*the spirit of religion and the spirit of science are going to join hands,* because the leaders of both religion and of science are coming increasingly to see life as a whole instead of from the pathetically narrow and unscientific point of view from which some in both fields have in the past looked upon it. This is one of the places at which you young graduates have your greatest opportunity to exert a very large influence upon your generation.

I should like, in closing, to call the attention of any man who is wondering whether after all there is any progress, whether mankind gets farther away from the method of the jungle, and develops any more of the spirit of science, or of the spirit of service than he had in the past, to two recent events. Both of these events seem small, but I think they are pregnant with meaning and with encouragement for the man who has begun to wonder whether human society can ever really catch both the *scientific spirit and the altruistic spirit* and realize the immense possibilities which are before it when it does.

My first event is in the field of medical education. I am informed by my medical friends that the medical fraternity has actually educated itself up to the point where allopaths and homeopaths have got together, to abolish, so far as they themselves are concerned, sectarian schools of medicine. The last of these particular sectarian schools, so I am told, has gone, having been simply and rationally combined into schools which teach merely *medical science* as it is known today. Truly "the thoughts of men *are* widened with the process of the suns!"

The second ground for encouragement is found in the following fact: A statement upon the relations of science and religion was recently drawn up, which Bishop Johnson of Los Angeles characterized as a "thoroughly pious statement." It asserted that religion and science were not only not antagonistic, but that both were necessary to the progress and the happiness of mankind. Further, this statement definitely recognized God, for whom I myself want no better definition than that given by Tennyson when he wrote, "For I doubt not through the ages one increasing purpose runs," and it definitely assigned to religion an even more important place in human life than to science. On the other hand, it called for the recognition by all the signers of the scientific method. *Fifteen sixteenths of all the scientists to whom that statement was submitted signed it at once without a question as the statement of their belief,* and these men were chosen, let it be remembered, solely because of their outstanding character as scientists and with-

out any knowledge of their religious views. Three fourths of all the men of affairs approached signed and none expressed dissent, a few, however, preferring for political reasons not to join in the statement. Two thirds of the religious leaders who were interrogated signed, most of whom were of the more conservative groups. The response of the scientists is particularly significant and possibly has some bearing upon the breadth of view developed by scientific training. After this showing who is he who is asserting that science is materialistic and irreligious? There are a few scientists, it is true, but only a few, who forget the scientific method when they touch the field of religion and scoff at it without knowing anything about it, and these men, too, have their exact counterparts, perhaps in slightly larger numbers, in the field of religion where there is, I regret to say, a group of blind leaders of the blind, men who still follow the method of the jungle and are still imbued with its spirit of prejudice, preconception and intolerance. Yet there is here the best of evidence that the leadership in both science and religion is in the main imbued with both the spirit of intellectual honesty and objectiveness which is characteristic of science, and the spirit of altruism and service which is the glory of religion. *This combination is the only nostrum which there is for human ills, the only hope for a paradise on earth, and each of us has the opportunity to do his bit toward bringing it about.*

R. A. MILLIKAN

NORMAN BRIDGE LABORATORY OF PHYSICS,
CALIFORNIA INSTITUTE OF TECHNOLOGY,
PASADENA, CALIFORNIA

THE BUILDING OF THE NATIONAL ACADEMY OF SCIENCES[1]

THE architectural character of the building has been largely determined by its surroundings, being what Charles Moore calls the "Spirit of Washington." While classic in its appearance, it is not severely formal and lacks the rows of columns so familiar to the visitor to the National Capital.

The general character of the exterior is Greek even to the varying of the height of the masonry courses.

Across the doorway is a marble pseudo-pediment, wherein the sculptor has portrayed the elements with which science and scientific research deal—Earth and Cloud through the various forms of the Vegetable and Animal Kingdom to Man. At the apex is the Sun—the source of warmth and light.

[1] Abstract of a memorandum to the Carnegie Corporation of New York on the building designed by Bertram G. Goodhue for the National Academy of Sciences and the National Research Council, and the progress of its construction.

A great range of window openings two stories in height, three each side of the entrance, is filled between the upper and lower windows with low relief bronze panels figuring the outstanding Founders of Science from earliest times.

Within the main doorway lies a simple vestibule from which the great Foyer Hall is entered. At the beginning and end of this hall are elaborate grilled glass screens with panels of the Zodiacal signs set in an intricate framework of bronze. The ceiling is of cedar—colored and gilt. On either side of the hall are staircases and elevators. On the left beyond these is the library, and still further beyond, its attendant reading room occupying the very end of the building.

In the right wing of the building balancing the library is the small Lecture Hall, and beyond it the Meeting Room. The library takes the form of a central aisle with alcoves on either end. All here is of masonry and metal, even to the bookshelves.

The Reading Room is of more domestic appointment, panelled in walnut for about two thirds of its height, with a ceiling of walnut. The space between is now of plaster but may eventually be filled with a painted frieze.

The small Lecture Hall has been designed mainly with a view to its acoustic qualities. Above the high wainscoting of wood and panel, the wall is of acoustic tile. The ceiling and its heavy beams are of plaster.

The Meeting Room next to the Lecture Room is of the same size and proportion as its counterpart, the Reading Room at the extreme other end of the building, but it is less domestic in character on account of its purpose. As in the Library and Reading Room there is an ample fireplace.

The second screen in the Foyer Hall leads into the main Auditorium, which is cruciform in shape, the four arms being vaulted to support a central pendentive dome. The floor is of marble and green slate and three balcony fronts, each supported by two shafts of Verde antique marble, are of walnut with various inlays of other wood. The walls to the center of the arches are of acoustic tile and are as simple as possible in character and surface.

Above the spring, the arches and dome are genuinely vaulted and covered with acoustic tile, in its turn covered with elaborate decoration with panels of figures and emblems, the whole colored and gilt.

In the apex of the dome is an "eye," which is an accomplishment of scientific engineering. The roof of this "eye" swings upon itself in a way that permits the direct rays of the sun to enter at all periods of the year and day, and be projected to a spectrograph at the level of the floor under the dome. From this "eye" also depends a Foucault pendulum to demonstrate the rotation of the earth.

Both pendulum and spectrograph are removable