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THE ADDRESS OF THE PRESIDENT

SCIENCE AND THE FUTURE

E. J. CABLE

We are truly living in a wonderful and fearful period so far as civilization is concerned. Our present social order has changed so rapidly within the last quarter of a century as to cause many writers and students of sociology to become somewhat alarmed as to its future stability. The concept of progress is one of the most profound and germinal ideas at work in our modern age. Progress is but the interpretation of the long history of mankind and the development of a philosophy of action in a world of bewildering changes. To understand such progress implies that man by making use of science and invention can progressively emancipate himself from plagues, famines, social disasters, and may, if he so chooses, subjugate his material forces to the good of human living. Progress in civilization is most intimately associated with democracy, with advances in the natural and physical sciences, technology and social amelioration. In this 20th century it is no longer a theory; it is a reality. We have only to look around us on every hand to see its achievements. Disease is being stamped out, pain is being silenced, the span of life is being lengthened, comforts and conveniences are being provided, sanitation is being applied to multitudes, and knowledge is being popularized for the masses through startling new instruments of transmission and reproduction.

The 20th century has witnessed many important discoveries which have and are exerting such wide spread influence upon human thought and action as to arouse suspicion on the part of some, as to their ultimate values. To a few alarmists, these man-made discoveries are influencing the physical, the intellectual, the philosophical and even the social and spiritual well-being of man in the wrong direction. The result of it all is, we are creating, according to these propagandists, not only a lop-sided, but a top-heavy civilization. What has the message of scientific discovery to offer for the present and the future? Is it a message of hope, of inspiration, of optimism, or is it one of pessimism and ultimate defeat?

It may be true that science has progressed so fast that some facts have been misrepresented and that there has not developed an equally sincere understanding of the complex problems underlying our present social order. Can it be said that the scientist has been too busy in his laboratory looking through his microscope and telescope computing the distance of stars and the possibilities within the realm of the atom, to properly appreciate his obligation to our rapidly growing social order? It may be true that the scientist is really failing to do all that he can to enable the masses to secure a proper and adequate conception of the present application of scientific discovery to civilization development. Has modern science that dates from the time of Copernicus, Galileo, Descartes, and Newton evolved a new kind of science of a peculiar quality that not only overshadows, but in truth, destroys our old conception of civilization? Possibly it has, for one of the most distinctive facts about our present scientific progress is that it undergoes a perpetual and rapid change, but is not this as it should be? If I understand progress correctly, the only true ideal for civilization should be evolution and advance rather than stability and stagnation. If progress is essential in the development of civilization, that progress has and must come as the gift of true scientific research, for of all forces it is science, and the knowledge that it furnishes, that deters man from making overhasty conclusions and encourages him to replace all panicky emotions by sane, reflective, informed and rational thinking and acting.

Today modern science stands condemned by some alarmists because they fear that we are gaining new knowledge and acquiring control of new forces faster than we are able to develop our abilities to control ourselves, and that eventually our entire social order will collapse. To this modern tendency is laid the evils of the great world's war, our present economic and social unrest, and the general breakdown of our very democracy. It is this very fear, no doubt, that caused some shouters for a "science holiday" because they think that "science is the devil causing the world's economic growing pains." The spread of the idea that science takes away jobs or is at the bottom of our social and economic ills is vicious in its possible social consequences. Now the fear of too much knowledge is not a new conception. It is as old as the human race and has its genesis in the cradle of ignorance and superstition. To many, the pure scientist is being held up as responsible for our present dilemma. But why condemn the pure scientist for something for which he in no way is responsible. If someone must be

blamed, why not condemn the inventors and the engineers who have avidly seized upon certain details of pure scientific discovery and with the aid of the capitalists, who are seldom influenced by altruistic motives, have succeeded in revolutionizing industry and all material lines of progress so as to bring about these grave and serious difficulties in our entire social set-up. I have little sympathy with some of our modern pessimists who condemn the pure scientist because he has gone so far in the field of pure research as to set free from the womb of matter a veritable Demagorgon which is already beginning to turn against man and rend him, as well as the whole social organism which he has so patiently evolved; neither am I alarmed that man, in the final analysis, will become a mere parasite of machinery, an appendage to our enormous productive system of massive and intricate machinery. I am not so pessimistic as to think that man cannot be trusted with abundant knowledge of this physical world in which he lives. Writers like MacDougal, Robinson, Veblin, and Haldane raise the alarming question as to whether, "Man is not finally to become a machine-minder engaged in mere repetition work, the goal and ideal, toward which our modern social order is tending." No one could have visited the Century of Progress in Chicago and not have been stimulated by witnessing, as I did, the tremendous progress which science has made in the last 100 years. In the Middle Ages man groped blindly about in mental darkness, as it were, seeking to discover some clue whereby he might be able to mold the forces of his environment in such a way as to make them serve him rather than to enslave him, but with little success. Today, because of pure science, and the freedom granted to the searcher for truth, a new day has dawned. The pure scientific researcher has gone about to discover new facts and formulate new laws in such a way that he has discovered the secret whereby his greatest obstacle, namely, his environment, cannot only be modified, but in many instances entirely changed and made to serve him, and not to enslave him. The Century of Progress has emphasized, as nothing else could have done, a new national psychology of progress along all lines of applied science. It has created in the minds of millions of people a new national feeling of satisfaction, optimism and ambition, and has visibly demonstrated once and for all, the great debt that modern civilization owes to science.

No sane mind can reflect on any of the ancient civilizations and get from such reflection much to encourage the return to such indescribable human slavery. "Witness if you will, the ancient

triremes driven through the waters by power furnished by the sinews of thousands of human slaves chained to the old wooden oars, and then transfer yourself to the modern oil-burning ship where even the work of the stoker, who "hard fate" has often been held up as one of the terrible evils of our mechanistic age, and observe the ease with which he guides the great Leviathan of the deep by simply pressing the electric button which quickly and quietly releases hundreds of thousands of man power represented by the energy of separated hydrogen, oxygen and carbon atoms." "Again, behold, if you will, the ancient works of art of Greece, Rome, or the pyramids of Egypt, built by great ancient civilizations, but at the terrible expense of the worst kind of human slavery, and then witness the ease with which our modern Titans, energized by coal and oil, have freed man from the bondage of slavery with which earlier civilizations were enchained, or again sit down in your comfortable home, push the electrical button and listen to the strains of some great symphony wafted through space on invisible ether waves, and then ask yourself, has the pure scientist gone too far in relieving mankind from physical bondage."

Should it be made possible for a sort of emotionalism and misunderstanding of an uneducated public in this day and age to set up bars to further progress in scientific research? Have we reached a period in the building up of our social organism when science is no longer needed? Is it now time for the physical and biological sciences to cease all further scientific research? If so, then mankind is certainly doomed, for physics, chemistry, and genetic biology and their allies are the great fundamental constructive sciences which unlock the doors of all future progress.

It may be that we have some few scientists who are not honest and sincere in their investigations; men who do not possess the broad culture and training that is so necessary to distinguish between what is right and what is wrong, between truth and error, and what constitutes real constructive investigation, but I am quite sure that the number is very small. On the other hand, I am also quite convinced that we have many men and women working in other fields of art and literature who are just as destructive to the building up of a healthy, sane social order as the insincere scientists. One has but to read the cheap, trashy fiction fed to the eager reading public today or listen to the light, meaningless, and often debasing jazz strains over the radio, or view some of the ugly, unbridled license in art and motion screen pictures to *understand* that there is a base and sordid commercialism abroad in our land

which is exerting upon the life of the young a far worse devastating and destructive influence than anything produced by the fickle scientist.

It is true that the most outstanding progress in the last 100 years has been in the field of the physical and allied sciences and in the realm of biology. This is only natural, however, since the main urge has been for man to understand more fully how to control the factors of his natural environment and make them serve him. Thus physics, chemistry, astronomy and biology have brought such great and lasting benefits to mankind as to at once command the respect, admiration and unstinted support of all of the civilized peoples of the world.

There is another reason, I think, for the rapid progress in the above sciences. The supreme test of any science is its power to predict results. It is here that the physical sciences reign supreme. Unlike psychology, economics, and many of the other so-called social sciences, the pure scientist is able through arduous labor and brilliant experimentation to forecast with a certain amount of surety certain definite results because of the application of the well-known laws of terrestrial mechanics, of force and motion, of thermo-dynamics and electro-dynamics. No such mechanistic scheme of exploration, as yet, can be applied to psychology, or any of the other social sciences. We have not been able to apply to our economic, social, and political life any kind of exacting or predicting science, and until we can these sciences must be more or less chaotic. We will have to admit, whether we wish to or not, that the scientific researcher in the field of the physical sciences has given us, and will continue to do so, the most complete knowledge of the nature and possibilities of our physical, ethereal and biological world, and it may not be too much to say, our intellectual world also.

It is a long span in thought and actual realism from the ox-cart and the covered wagon to the steam engine, the electric railway, the automobile and the airplane. It is likewise an equally envious record from the signal flare of the red man, the foot-messenger and the pony express to the telegraph, the wireless and the radio. These rapid and efficient means of transportation and communication, the result of the untiring efforts of the pure scientist and the application made by the inventor and the engineer, have and will continue to create greater changes in our social order. New bonds between peoples, new interdependency for food, clothing and shelter, and educational ideals have introduced new and intricate prob-

lems into our present-day sociology. Life has speeded up over that of our forefathers, and will continue to speed up as science advances. Living will become more complex, and because of this very fact, man should not shut his eyes to the truth, nor should he be refrained by fear from searching for the truth, unless he again wishes to consign himself to a stage of savagery. One of the outstanding questions that confronts man is this, is he intelligent and wise enough to control properly the forces which he has and will set free? Will all the complex and intricate machinery which he has produced, and the vast store of knowledge which he has already gained and will continue to accumulate in the future, become his servant or make him its slave? Science will give us still more complex and powerful machines. New sources of energy will be tapped and harnessed to man's machines that will make the energy of the present seem but mere child's play. Already we have visions of such a fact when we examine the discoveries that are being made in the realm of the physical sciences. Physics has not passed into senility, as many writers years ago would have one believe. New vistas are opening up rapidly. The pushing outward of the limits of known space which has occurred in the last decade is one of the most marvelous and thrilling advances in astronomy, the hand-maiden of physics. The work of Hubbell and Humason has shown that there are other great star systems scattered through space as far as the telescope can penetrate which have furnished an actual basis for the mathematical theories of Einstein and a host of other workers in the new field of physical astronomy. "The history of physics in recent years is largely a story of the spectrum of ether vibration that begins with the slow pulsation of electrical current and continues with increasing shortness of wave length through radio, heat, light, ultraviolet, x-rays, radium, and cosmic rays, and where will it all end?" No one can at present forecast. What sane individual dare say that such outstanding researchers as the late Michaelson, or Millikan, Morley, Einstein, Eddington, Jeans, Rutherford, Bohr, Compton, Pupin, Davisson, Germer, Nichols, Tear, and a host of others are not sincere in their research for the truth about this physical world of ours? Shall we call a halt to their efforts for fear they will ultimately discover some new hidden source of power that may some day destroy the human race?

It is no time to call a halt to researches in the realm of inorganic and biological chemistry. We do not yet know enough in these fields to enable man to live wisely and completely. Many of the

world's new industries have arisen out of the researches and discoveries in chemistry. The whole vast petroleum industry, vulcanization of rubber, electrolytic processing of aluminum, the manufacture of celluloid, rayon, high speed steel, collodion, and a long list of useful products have resulted from the labors of the pure scientist. Likewise, in chemical biology the discovery, isolation and application of internal secretions, or hormones, has opened up an entirely new field for pronounced progress in the realm of physiology and medicine. Researches in the field of organic chemistry have given us a new conception of proper food diets, and a new and valuable knowledge in the fertilization of worn-out soils.

There are discoveries in still other fields of science outside of the realm of the physical sciences that have contributed greatly to society's enrichment. Take for instance the advance made in the science of bacteriology and medicine. Man's expectancy of life and health has been prolonged by some 20 years beyond that of his grandparents by the unselfish labors of the pure scientists whose names are as illustrious as are those of Copernicus, Newton, Kepler, Galileo, Farady, Maxwell, and Hertz in the field of physics. Who can read and not be inspired by the labors of Ignac Semmelweis, the savior of mothers, or Banting, the discoverer of insulin, or Minot, the finder of the cause of pernicious anemia, or Spencer, the conqueror of spotted fever, or the work of Evans and McCoy on malta fever, or the researches of Fritz Schaudin, Jauregg and Wagner on the deadly spirochetes germ, or Nagouchi's sacrificial death for the eradication of yellow fever, or Nels Finsein's work on the light cure.

If physical knowledge is social knowledge, then it must be equally true of biological knowledge. The great advances made in this realm in the last hundred years have inspired man with a new vision, a new hope, and a renewed effort to still better human existence and to bring about, if possible, a final race solution. A good remedy for the disease of crash materialism in science, if there is such a thing, is to read the history of the progress made in this field. One is thrilled as he reads of Galen, the brilliant scholar who laid the foundation for the study of anatomy; of Vesalius, the Belgian, who first introduced the laboratory and experimental method for the study of biology; of Harvey, the sire of physiological science and the discoverer of the human circulation and the first to direct attention to the study of structure and function; of Linnaeus, who introduced for the first time the bi-nomial system of nomenclature; of Cuvier, the founder of vertebrate paleontol-

ogy; of Von Baer, the discoverer of the germ layer theory; of Leeuwenhoek, the developer of the microscope and its use, and the revealer of bacteria and protozoa; of Lamarck who first set forth the theory of evolution; of the brilliant Darwin who startled the scientific world with his theory of natural selection as a basis of evolution; of Mendel, founder of the Mendelian laws of inheritance; of Pasteur, to whom biological science is indebted for immunization and the germ theory; and in more recent times, to T. H. Morgan, the geneticist whose work on heredity has greatly added to our present knowledge of biological processes; to Guyer, researcher in the field of inheritance of acquired characters; to DeVries, investigator on evolution by inheritance; to Mueller's researches on increasing mutation by the x-ray; to Child's investigation on senescence, and to Evan's exploration in the field of vitamins. These are but a few of the multitudinous illustrations that could be cited to properly inoculate disbelievers as to the value of pure scientific research in the field of biology for the enrichment and betterment of the human race.

Had we time, we might cite equally illustrious progress which has been made in the fields of agriculture, geology, paleontology, and petrology.

If there is any optimism to be found in our modern social order, and if there is any hope for the future, then I believe that we must find it in the unselfish, sacrificial labor of the pure scientist. If there is any pessimism as to the ultimate value of his labors, and there is some, it can only be softened when the discoveries of pure science and their application to modern life are properly understood and wisely applied.

What we need now is not less of science in our educational system, but a more intelligent knowledge of science; not a knowledge of science particularly for the technician and the engineer, but for the masses. More of our people must come to appreciate that there is a vast difference between truth and error; that one opinion is not necessarily as good as another, and that there are certain fixed laws that govern this physical world of ours. When the masses come to understand the true mission and intent of science I am sure that there will be little fear of endowing the human mind with too much power.

If you believe with the "shouters for a science holiday," that too much knowledge is dangerous; that man cannot be trusted with vast new resources of power; that such knowledge and power will ultimately mean the entire disruption of our social organism, then

use your influence to bring about a closing up of all of our centers of scientific research and the abolishment of all scientific organizations. If, on the other hand, you take the attitude that knowledge is essential to all human progress, and that to its door cannot be laid the blame for our moral and social relapses, then use your influence for the continuance of true, sincere scientific research.

If scientific research is not responsible for the sad moral plight in which the world finds itself at the present, but on the other hand, is largely due to the wrong application of its discoveries through the misdirected efforts of the engineer and the capitalist, then let us apply the remedy where it belongs. I think I can say without fear of contradiction, that scientific research through proper applications of its discoverers has brought and will continue to bring about the most profound and beneficial social evolution that this world of ours has ever experienced.

By some few, our present age has been characterized as an age dominated by a pure physical realism, or a materialistic age, but no one who has a true perspective of the discoveries made in physics, chemistry, biology, and the rest of the sciences, can for one moment entertain such fallacious fanaticism. If the physical and natural sciences have shown the way to such momentous progress in helping to build up our present social order, why condemn them as breeders of grave and serious social wrongs. Might I ask, what kind of science are we to substitute for them? Will it be psychology and the other so-called social sciences? Have these sciences developed sufficiently far enough to be predicting sciences? Have we arrived at the point where the many imponderables involved in them can be precisely measured and evaluated? Until these sciences have reached such a stage, we may expect little from them in the way of remedy for our present social unrest.

I am one, however, who believes that what we need today is a sound, workable psychology which will become the foundation stone for all of the social sciences. It must, however, be a psychology based on sound biological principles, a systematically ordered or scientific knowledge of human nature, which, after all, is the very life of society. Today we have no such a science, but that is no reason why we should not encourage the development of such a science which will involve the social sciences, economics, politics and all the others. The world will certainly welcome the day when such a science can be developed to the point of a predicting science.

I believe that instead of condemning the physical and natural sciences for the progress they have made, it would be much better

to urge that sufficient time and money be expended for the development of the so-called social sciences. It might be wise for our universities and schools of research to establish and endow departments and provide the same with means whereby our well trained and promising young men and women could pursue for an extended period a real scientific approach to these sciences.

I am very sure, however, that we will never be able to build up a sound healthy and scientific psychology in a short time. It will require years of serious and intensive research, that has in it a knowledge of our biological and physical sciences. When such an attack has been made, our present psychology will pass from the realm of dogmatism, enigmatic statements and chaos to a real science where we may find hope of some sort of positive predictions. When this time comes, as come it must, we will have gone a long ways toward the solution of many of the ills that exist in our present social organism.

I do not fear that we are coming to the end of pure scientific research. If I read the trend of the present administration, pure scientific research is to be nourished in the future rather than discouraged. Already an Advisory Board to the nation has been appointed by the President to serve for a period of two years. It seems now as if the nation has reached a point where it no longer is to be guided by blind dogmatism, but by scientific research. Administrators are now desirous of securing facts for social guidance. All the resources, methods, possibilities and limitations must be made known before curative remedies can be engineered. No information of such an important nature can be secured quickly, nor can it come by guess or hunches, but only by tireless and passionless research. Such a procedure is assuring to the scientist, and to aid such an undertaking, the President of the United States has selected with great care, outstanding leaders in the field of science and technology. It will not be amiss here to scan the list and take note of the various fields represented. Chairman, Karl T. Compton, physicist, and president of the Massachusetts Institute of Technology; W. W. Campbell, astronomer, and president of the National Academy of Sciences; Isaiah Bowman, geographer and chairman of the National Research Council; Gano Dunn, engineer, and president of J. G. White Engineering Corporation; Frank B. Jewett, engineer, and president of the Bell Telephone Laboratories; Charles F. Kettering, engineer and president of General Motors Research Corporation; C. K. Leith, geologist, and professor of geology at Wisconsin University; John C. Merriman, paleontol-

ogist, and president of Carnegie Institute at Washington, D.C.; and Robert A. Millikan, physicist, and director of the Norman Bridge Laboratory of Physics. This Board is already at work on a very searching appraisal of the scientific institutions of the government and their final report may determine the pace of progress for a century or more.

I am quite sure that such a survey is going to be based on the positive assumption that we are to go forward—that there can be no thought of scuttling any serious lines of earnest scientific endeavors, or the abandoning of any new fields of knowledge, in spite of the fact that there are a few nostalgic individuals who still lament the passing of the good-old-times, the shifting of labor from the backs of slaves to the man-made machines, and many other new-fangled ideas which these few well-meaning individuals charge as sinister evils to our present scientific revolution.

If we can place any faith at all in the philosophy of John Dewey, then we will have to admit that the great scientific revolution is not yet upon us, but will be born just as soon as men collectively and coöperatively can so organize their knowledge as to secure and stabilize real social values. I do not see how this new idea of collective and coöperative organization in any way calls for any regimenting of science into some uniform sort of goose-step discipline; such a procedure would be fatalistic to science, but I think that it does mean the development of a national awareness of just what is being done, and is, therefore, a national move to encourage and foster research along the entire front so that new discoveries and new inventions may be promptly and wisely applied for our social betterment.

Research in America is a multiform activity. It is carried on in our universities and colleges, technical schools and endowed foundations. Such institutions as the geophysics Laboratory at Washington, the Norman Bridge Laboratory at Pasadena, the Rockefeller Institute of Medical Research at Yonkers, are but a few out of many others that might be cited.

Research work has increased very rapidly in the United States in the last 25 years. In 1906, there were about 4000 men and women engaged in research work in all of the sciences, while today, there are about 22,000. This entails an annual outlay of about \$200,000,000, \$40,000,000 of which is provided by the National Government. A recent critic of the National Government expenditure, and a business man at that, challenged a prominent scientist in the Department of Agriculture, to justify, on a purely economic

basis, the practical benefit of the expenditure of such a large sum of money. The scientist did not guess, but went directly to the files of crop statistics and soon secured data to show that for every dollar spent in plant research, \$500 had been returned, or a gain for pure scientific research of 50,000%.

There are researches going on today in all fields of science that assume a universal beneficence which transcends the accounting houses to measure in terms of monetary value to mankind. I am quite convinced that Dr. Compton was right when he said, "That if one-tenth of the money which has been lost during this depression had been put into a wisely planned program of research, the other nine-tenths would not have been lost." The mission of the Advisory Board is to guide the government to some sort of a permanent policy, which involves the systematizing of all government research under a national policy, the aim of which may be the emphasis of social values rather than competitive or purely commercial advantages. Such a policy, however, should be motivated and guided by the procedure of the pure scientific researcher. No snap-shot judgments should be accepted. Long range investigations should be the procedure rather than immediate emergency opportunities. Pure science, in our present national emergency, is fundamentally primary and necessary. It will be a serious mistake and an unpardonable blunder to hurry up research work in order to find some seeming panacea for our present and seemingly chaotic social order. This fact was forcibly brought home to us during the great world's war. We gained little from a mushroom procedure of research. It takes a long time from the inception of a new idea until the practical application of it can be applied to society. Dr. Merriman has well put it when he said, "I do not know that necessity is the mother of invention, but I am quite sure that scientific curiosity is." "We discover and invent only after trying out all the possibilities by putting this and that together, by exploring the unknown frontiers for the joy of the hunt."

All research, therefore, must be of the long-range type, and no Advisory Board should consider any political pleading for governmental purposes sufficient reason for curtailing or hastening true scientific research, if our people as a whole are to ultimately profit thereby.

This Academy, as well as all other true scientific bodies of good repute, are engaged in real worth-while discovery of truth as it exists in Nature. We should not, therefore, be too much disturbed by the present spirit of revolt abroad in the land. The

bizarre, the sensational, the extravagant criticisms are but a transient bubble on the deep sure flowing stream of scientific progress. Sooner or later the public will come to understand and appreciate that science, the foundation stone of any lasting civilization, changes only when new irrefutable knowledge is acquired, and not because change is the fashion. Our mission as teachers and investigators is to help, in every way possible, to create an intelligent public; a public that can appreciate that real truth once established always remains truth, and that truth is not a barrier to social betterment, but on the other hand, a worthy handmaiden.

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