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SOME OBLIGATIONS AND OPPORTUNITIES OF SCIENTISTS IN THE UPBUILDING OF PEACE[1]

WE have been free from the turmoil of actual warfare for something over a year and it is high time we turn our faces with resolute courage toward the coming years with the determination that the world shall be a happier, saner, and safer one for humanity. The results of victory have probably not been all that we expected and certainly not all that many of us desired while in many respects the results have been entirely unforeseen. To scientists, I imagine, one of the most surprising outcomes of the war has been the sudden and I believe permanent enthronement of science in the activities of humanity. In the carrying on and the winning of the war, men of science played an unexpectedly important and indispensable part. The roll of honor among the sciences is large and includes certainly all of them represented here to-night. The men in these sciences were called from every quarter of the nation; and the promptness with which they answered the calls and the effectiveness with which they met the demands made upon them should be a source of pride and profound satisfaction to every one of us.

THE STANDING OF SCIENCE IN THE MINDS OF THE PEOPLE

As a result of their work the value of research and investigation to the welfare of the nation, whether in peace or in war, has taken hold on the minds of the people as never before; and the worth and usefulness of the scientist to humanity have received general recognition from the public to an extent long justified but hardly expected in our day and

[1] An address delivered at the installation of the new members of the Alpha Chapter of Sigma Xi at Cornell University, May 18, 1920.

age. As one clear evidence of this I cite the adoption, by the American Federation of Labor at Atlantic City, of that noteworthy resolution with its remarkable preambles concerning the importance to the nation of scientific research. The resolution is well worth repeating here and is as follows:

Resolved, by the American Federation of Labor in convention assembled, that a broad program of scientific and technical research is of major importance to the national welfare and should be fostered in every way by the federal government, and that the activities of the government itself in such research should be adequately and generously supported in order that the work may be greatly strengthened and extended; and the secretary of this federation is instructed to transmit copies of this resolution to the President of the United States, to the president pro tempore of the Senate, and to the speaker of the House of Representatives.

The five preambles preceding the resolution set forth in a very clear, cogent manner the importance of research to the development of our industries, manufacturing, agriculture, mining, to increased production, and to the general welfare of the workers. One can not fail to realize that the accumulated achievements of science prior to the war together with the accomplishments of scientists during that terrible struggle have created a heritage for future generations of research workers from which they may "take increased devotion" to their chosen pursuit. Although we may feel gratified with this background of the status of research and with the present position of science we must not forget that there is another and serious side to this situation. We must not forget that this world confidence in our work and reliance upon us for future accomplishment put upon us an enormous responsibility and a high obligation to show ourselves worthy of the faith and equal to the expectations of humanity. Moreover, we are now in a position where we must make a determined effort to meet these added obligations and live up to them in the same devoted, courageous, unselfish spirit of achievement with which this heritage has come to us and we must carry them on with energy, effectiveness, and joy. What, then, are some of the obligations and opportunities of the scientist in the coming years of peace?

Opportunities of Scientists in the Social Welfare of the People

First of all it seems to me that the student of science will necessarily take a more active part in certain directions, at least, in attempts to aid in solving some of the social and perhaps political problems of the people. Indeed it appears to be his duty to do so and the opportunity is worthy of the man. As a case in point with which I have been much impressed was the partitioning of Austria-Hungary by the Conference of Paris. Simonds points out very forcefully that in this partitioning there was created one state rich in minerals and possessing considerable industrial machinery but having no areas of soil on which food can be grown for the support of its people. Another state was created containing the city of Vienna which apparently has no sources of food, of raw materials, or of any of the elements necessary for self-maintenance, while a third state was set apart that has no minerals and few raw materials but can produce more food than is needed for its own consumption yet it was given no outlet to the sea and was left with no means of transportation by which products can be exchanged between it and adjacent states. Thus the economic situation created by academic statesmen and politicians is an impossible one. If the technically trained civil-engineer, mining engineer, geologist, soil technologist, and agronomist, for example, had been sent to study the regions and their data had been laid before the Conference and the vital bearing of their findings on the economics of the situation had been pointed out, perhaps, as Simonds says, from another point of view, the eggs would not now have to be wholly unscrambled in order to make living conditions for those middle European people possible. Certainly the opportunity for the scientist in this political matter was and is

yet, I believe, perfectly evident and the world should be made to understand it.

Another field in which the scientist must take a more active part in certain social problems of the people is the direct outcome of a state of affairs which his own efforts have produced. I refer to the results of research in the industrial world and the effect on the social condition of the worker.

The researches of science in the industrial world and the enormous development of specialized machinery and processes of manufacture have resulted in producing great inequalities in the social life of the people. These researches have certainly resulted in giving power to a few men and in belittling the position and character of many men, notably, the individual workers. The technical results of industrial research have made possible the practical control of the world's production of clothing, furniture, much of its food, and means of transportation by a comparatively few men. Industrial research and development have made some men very rich and caused a great many men to remain uncomfortably poor. I do not mean to say that the laborer is not better off to-day in houses, supplies of food, clothing, entertainment, and the general comforts of life than he has ever been in the history of the world, but I do say that he is tending to become more of an automaton, more of a machine, and less of an individual and that he is still living largely under sanitary and health conditions that are wholly incompatible with the advancement of the age and our present knowledge. These effects on the worker and on society are some of the paradoxes of industrial scientific research and investigation. And it appears as though further activities of this line of research will tend still farther in the same direction, yet the need for similar and more intense investigation, as I shall try to point out, is absolutely imperative and more pressing than ever before.

Unquestionably the major problems of social welfare must be left to the student of humanities who is especially equipped by his knowledge of the philosophies, religions, languages, racial temperaments, and histories of man, to deal with these questions. Yet I believe the scientist may do much to alleviate the effects of his industrial researches and, it seems to me, he has an obligation in this matter to meet and a duty to perform which perhaps have not been fully realized. The laboring men, in one of the preambles to the resolution which I have read, have already indicated the direction in which a part of the effort of the scientist must go in this matter. In speaking of the importance of scientific research the laboring men said "and the health and well-being not only of the workers but of the whole population as well are dependent upon advances in medicine and sanitation." In this direction, then, may lie some of the efforts of the scientist to ameliorate the unsatisfactory conditions brought about by industrial research. Certainly any improvement in the sanitary and health conditions of the laboring man will react upon his social welfare. Here the medical man, the sanitary engineer, and the biologist may find an enlarged opportunity and a chance to aid in undoing, as it were, some of the undesirable results that the scientist has unwittingly brought about in his zealous investigations. Indeed, in a wider way, anything that the scientist can do to vary the monotony of the laborer's job, to remove the danger of accident to life and limb, to relieve the abnormal strain of fatigue, or to improve the man's well-being in any way should be done and unquestionably the scientist has a duty in this direction to perform.

SOME PROBLEMS AWAITING SOLUTION BY SCIENTISTS

But aside from these questions which many of us will deem relatively unimportant there yet remain out of the many momentous problems facing the world to-day at least three which are pressing for immediate solution and a fourth one which needs new emphasis and added stress.

The problems to which I refer are: (1) the serious need for an increase in the production of the necessities of life; (2) the development

in the shortest possible time of more extensive and more efficient means of transportation; (3) the increase of the sources of physical power and force; and (4) the maintenance and increase of the ideals and the spiritual forces of humanity.

In considering the first three of these problems one can not escape the conclusion that the scientist should and inevitably will be one of the chief agents upon whom the world must rely for aid in the solution of them.

THE PROBLEM OF INCREASING PRODUCTION

The world to-day is facing a serious shortage of food supplies, which, in some European countries, has already reached the acute stage of famine conditions. In the United States the farmers are facing a labor shortage which in many cases is actually curtailing production, while some, having arrived at an advanced age at which their physical stamina is not strong enough to withstand the discouraging situation, are not only disposing of their farms but are actually abandoning them and adding themselves to the already great army of unproductive people in the towns and cities.

In this situation the trite and familiar saying that "he who makes two blades of grass grow where one grew before" takes on a new meaning—a meaning not only of fame and altruism but of dire necessity to the human race. The chemist and the soil technologist must show how the farmer can produce more per acre; the engineer must devise machinery for the production of crops on an increased acreage with lessened labor; the physicist, chemist, and electrical engineer must show us how to get more and cheaper supplies of nitrogen; the plant breeder must develop more productive varieties of plants; and the zoologist and botanist must find better methods of protecting the crops produced from destruction.

It is not, however, in food alone that we are suffering from an underproduction. It is the same story in clothing, household furnishings, building materials, farm machinery, and other vital supplies; and in the face of it all the laboring element is struggling for shorter hours of labor and certainly in general a consequent lessened productive capacity per man. The laboring man of America appears blind to the fact that his higher wages, greater comfort, and general prosperity over that of his European contemporary have been due primarily to his greatly increased productive capacity under the conditions of industry as carried on in this country. And his utter fatuity in attempting to curtail the very thing that contributes to his well-being is one of the amazing things in the world to-day. In spite of this paradoxical attitude the laboring man is struggling for more leisure and seems destined to attain it.

THE PROBLEM OF INCREASING THE MEANS OF TRANSPORTATION

Turning for a minute to our second problem, the necessity of better and more economical means of transportation, let us recall briefly the conditions as they exist to-day. Competent authorities estimate that the country's transportation needs in the last six years have increased 45 per cent. while the railroad facilities have increased but 2 per cent. We are told that from 300,000 to 800,000 new freight cars and from 1,000 to 2,000 additional engines are needed at once while Europe is infinitely worse off than we are. It appears that some cities in southern Europe actually faced famine conditions for a time, at least, with supplies within reasonable distance but absolutely unavailable because no means of transportation existed to bring them within reach of the suffering community.

The transportation problem in this country has been developed by men whose principle aim in former years, at least, has been to make the railroads pay attractive dividends on the stock which has often been watered stock. The time has come, it seems to me, when the whole matter should be put on a thoroughly scientific basis by the technically, scientifically trained man. The permanent cure for many of the ills of transportation is to determine by careful scientific research and investigation more efficient and cheaper

types of power, fuel, engines, cars, and other equipment that enter into the problem. In other words, the costs of the means of transportation should be lessened rather than the price to the public increased. The answers to these questions will be obtained very largely by the investigator.

Intimately bound up with this whole question is that of public highways and their function as means of transportation. The motor truck or some similar and, I hope, more efficient vehicle, seems destined to revolutionize the methods of the interchange of products, certainly within the confines of reasonably limited areas. But in this matter, as in scores of others affecting intimately the welfare of mankind in this country, we have pursued a policy of *laissez faire*. We have bonded the state, taxed the people, built the roads, watched them crumble to dust and have then bethought ourselves of the desirability of an investigation of the principles of road making and of road materials. Unquestionably we shall awake in time to the necessity of a careful, thorough, extended investigation of the whole question of transportation. When that time comes the country will inevitably turn to the scientist for aid in solving the problem. The opportunity is inviting and I trust we shall have men trained for the work.

THE PROBLEM OF INCREASING THE SOURCES OF PHYSICAL POWER

The third problem to which I referred, namely, that of the need of increased or entirely new sources of physical force or power is a larger and really more basic question. The railroads of this country in 1918 used approximately 165,000,000 tons of coal. What the marine and stationary engines used during that year I do not know but the aggregate must have been large. From all of this vast amount of coal consumed in the United States for the purpose of generating force, approximately 90 per cent. of its heat was never delivered as mechanical power by the engines in whose boilers it was burned. What an overwhelming waste? And simply because of our present inability to avail ourselves of anything like the total inherent force or power that lies within this costly, steadily decreasing product, coal. In what dire need the world is of this latent but lost power! How much labor, energy, money, cargo-space, ships, and cars now used in mining and transporting coal could be devoted to other lines of industry and commerce if only one half of the latent power of this mineral could become available and that is the task that confronts the scientist. The last word on the means of utilization of this vast waste of power has certainly not been said.

Oil, our other great natural commodity from which we obtain physical power is already in greater demand than it can be supplied from our own fields. The situation is already acute and in less than a score of years the supply in the United States promises to be exhausted. Either new sources of oil must be found or some substitute must be produced.

Electricity, another of our great forces is now awkwardly obtained by expensively harnessing some mighty stream or by wasting nearly all of the latent power of coal to capture, as it were, this omnipresent, illimitable agency of force. There ought logically to be some method by which we could avail ourselves of this force in a more direct way—by reaching out, as it were, and taking it.

At the best then our present sources of physical power are very inadequately available or are hopelessly declining. In either event something must be done and done in the immediate future or we shall revert to semi-primitive conditions. It is to the scientist that we must look in large measure for the solution of this vital question.

In considering then, these three problems one can not fail to be impressed with the seriousness of the situation. In confirmation allow me to relate briefly a recent experience. Within the last week I received a letter from a company in New York City saying, "we can not make shipment of your material from New Jersey but we think we may be able to

send it from our stock here in the city if you are willing to pay the extra cartage." On the self-same day I received a notice from a company in Chicago saying, "the express companies are unable to handle express from Chicago to points in New York State." The next day the same company sent me notice that although they were preparing the order for shipment by freight the railroads in Chicago could not accept it at present and they feared there would be considerable delay in forwarding the order. These happen to be coincidents, indicative not only of the present condition of transportation but of much deeper and more serious social and political conditions. It is amazing and rather startling to awake and find that in this country of ours there is to-day but one agent of transportation actually and fully functioning —namely the United States Parcels Post. Unquestionably these conditions are partly due to the abnormal unrest in the minds of the people but what is much more serious, out of these conditions is bound to come further unrest, so that the end is not now in sight. In spite of one's faith in this beloved country of ours and in spite of one's boldest optimism one can not look forward without some fear and misgiving and our hope must rest very largely in the ability and the genius of our young men and women, especially in those who are trained to think and to work independently with the methods of research. If scientists can solve the problems we have touched upon they will not only contribute to the material welfare of the country but will also aid in allaying and finally settling the social unrest of the people. The obligations of the scientist in the upbuilding of peace are great and opportunity is knocking at the door of each one of us.

THE CONTINUED NEED FOR RESEARCH IN PURE SCIENCE

The discussion, so far, has turned mainly on what the world has long called, applied research. It seems to me that the term applied research is a misnomer and that it would be far more accurate and nearer the truth to designate it as research, applied. That is to say, in the solution of any problem by scientific investigation, no matter in what direction it may eventually tend, there must first be research, pure and intensive, accurate and often prolonged, followed if you please by an application of the principles so discovered. Thus we have had and must have in greater measure in the future, as I have already tried to point out, research, the resultant principles of which may be applied to the solution of economic problems affecting the public welfare. On the other hand, there is among men such a thing as research for the pure love of it. The characteristics, however, of such research do not lie in the method of work but rather in the spirit of the man doing it. The intensity of the work, the broadness of it, and the accuracy of it, do not differ one whit from the research work that may come to have an economic application. The differences between the two are psychological—attributes of the man. One investigator is absorbed in the beauty and sublimity of truth and in its discovery without any thought of aiding humanity while the other carries on his research with the hope that he may not only discover truth but that it may be of practical benefit to the human race. But these subtle distinctions if they really exist are of no consequence. What I wish to emphasize is, that work in pure science constitutes after all the most fundamental kind of research for humanity because it touches the spirit and the soul of mankind and everlastingly ennobles the human race. Pure research in science or in the humanities has been and still is the basis for all intellectual and moral progress and advance in enlightenment among all races and all peoples. And at this critical stage of civilization the spiritual force of this kind of intellectual activity needs new emphasis and added stress. The spirit of the pure scientist is the spirit that we desire to see pervade all humanity and all of the activities of humanity. It is a spirit of truth and honesty that tends to banish superstition, narrowness, greed, selfishness, and provincialism and to establish char-

ity, fairness, justice, and democracy. Indeed all high intellectual effort, whether in science or in the humanities, embodies this spirit. I can think of no happier illustration of this fact than the reply of the celebrated American artist, Edwin A. Abbey, when he was asked why he was so particular about the historical exactness of every detail, being assured that he was the only one who would know the difference. He replied by quoting the following verse:

> In the elder days of art,
> Builders wrought with greatest care,
> Each minute and unseen part;
> For the gods see everywhere.

He said:

> It is because I can't forget those lines that I must make things as right as I know how, even if nobody is the wiser. "The gods see everywhere."

It is this spirit of honesty with one's self for the sake of honesty and truth that pervades all genuine intellectual effort, whether in science or in the humanities, and infiltrates into the body politic of a nation comprising true scholars among its people. It is one of the imponderables of civilization and the more our nation indulges in it and fosters it the higher will our civilization be.

The men who live in the hearts of the human race as a source of inspiration and greatness are those that have unconsciously contributed to civilization out of the greatness of their souls and their work. It is not the great financier, the captain of industry, or the merchant prince who lives through the ages, but rather the men who have "contributed materially to the fulfillment of man's destiny and bequeathed to future generations some new particle of truth, of beauty, of justice"—a Michael Angelo, a Newton, a Shakespeare, a Darwin, a Pasteur, a Franklin, a Lincoln. It is the spirit of such men that lives in a people and makes a nation truly great. Lowell in commenting on the industrial accomplishments of this nation put the whole matter most aptly when he said it is

> with quite another oil that those far-shining lamps of a nation's true glory, which burn forever, must be filled. It is not by any amount of material splendor or prosperity, but only by moral greatness, by ideas, by works of imagination that a race can conquer the future. . . . Of Carthage, whose merchant fleets furled their sails in every part of the known world, nothing is left but the deeds of Hannibal. . . . But how large is the space occupied in the maps of the soul by little Athens. It was great by the soul, and its vital force is as indestructible as the soul.

This, I take it, is the spiritual force that we as students of the sciences must join hands with students of the humanities in maintaining and increasing in the world. And I am constrained to believe that, despite the apparent zeal for material development in this country, this spirit of moral greatness has ever been present here although, at times, it may have slumbered. If anything has been clearly demonstrated during the last five years it is that there are multitudes of young men and women that are ready and eager to give their all even unto death for truth and its corollaries, justice, freedom, and democracy. And it is appropriate that we here dedicate ourselves to the furtherance of this spirit and that we here resolve that we shall maintain it and if possible increase it in our beloved nation. It is you young men and women who must take the torch of intellectual idealism borne by many of your illustrious predecessors and pass it undimmed through the coming years to your successors.

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USES OF PLANTS BY THE INDIANS

PROBABLY many who are interested in wild plants have wondered what uses were made of them by the Indians before white men came. Dr. Melvin R. Gilmore has recently published[1] such an account (relating chiefly to the region of Nebraska) which it has seemed desirable to review in the following form.

While we are familiar with the changes

[1] "Uses of Plants by the Indians of the Missouri River Region." In Thirty-third Ann. Rept. Bur. Am. Ethn. (1911–1912), pp. 43–154, 33 pl., 1919.