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THE PUBLIC RELATIONS OF SCIENCE[1]

By Dr. WESLEY C. MITCHELL

PROFESSOR OF ECONOMICS, COLUMBIA UNIVERSITY

UNTIL recently the attitude of the public toward science seemed to be growing more appreciative. There have always been folk who objected strenuously to the supposed implications of certain scientific hypotheses, but on the whole science was generally esteemed the most progressive factor in culture, man's best hope for bettering his lot upon earth. Of late this tide of approval has ebbed. There is a widespread disposition to hold science responsible for the ills men are bringing upon themselves—for technological unemployment, for the rise of autocracies, for the suppression of freedom, for the heightened horrors of war. For their part, scientific men are appalled at the hideous uses to which their discoveries are put. They feel an urge to combat the misuses of science, to protect the social values they cherish, but what they can do is not clear. The quandary is one that all who cherish science should face, however unwelcome and difficult the task. I offer no apology for asking your attention to a discourse of uncertain issue on an unpleasant theme thrust upon us by developments we deplore.

[1] Address of the retiring president of the American Association for the Advancement of Science, Columbus, Ohio, December 27, 1939.

I

Let me start by recalling certain changes in the relations of science to society that may help us see our present problems in historical perspective.

The beginnings of scientific knowledge have been traced to man's dealings with the implements of his daily life—the sticks and stones, the skins, fibers and clay he shaped to his uses, and in the shaping learned to know. Human beings are born speculators; even the simplest cultures have their explanations of matters that puzzle us to-day—diseases, weather changes,

animal behavior, the creation of the world, what happens after death. Without this speculative bent human intelligence could not have evolved far; but neither could it win much useful knowledge without subjecting speculative explanations to practical tests. As the nursery of scientific thinking, the humdrum work of making and using household equipment had this great advantage: it required frequent repetitions under roughly similar conditions, when there was no great emotional stress, and when attention was centered upon immediate material results. In such activities it was least difficult to find out what operations were followed by the desired consequences, and what operations were superfluous.

Whether or not we accept this speculation about the humble beginnings of science, we know that at a later stage of cultural advance thinking about natural phenomena, like thinking about religious observances, tended to break away from direct associations with daily work. The slowly improving techniques of tracing the motions of heavenly bodies, keeping track of the seasons, measuring lands, developing mathematical propositions and erecting large structures called for unusual intelligence and training. Possessors of special knowledge wished to guard their trade secrets, to make mysteries of them, to initiate merely a few of their own choosing, and so increase their prestige. Mathematics is the subject least dependent upon the use of material objects, and it led the development of systematic thought, closely followed by its cousin, logic. Dealing with a rational universe of concepts, its affiliations seemed to be with religion and philosophy rather than with industry. So far as knowledge dissociated itself from technology, it escaped from continual subjection to matter-of-fact tests. That left it free to pursue attractive lines of speculation, but took away its most vigilant corrective and its sharpest spur to self-criticism. Even mathematical inquiry lost its momentum when it soared aloft in mystical flights.

Such efforts to understand the world as the Middle Ages made were concerned chiefly with problems of a divine dispensation. Observation was not pertinent, and factual tests of conclusions were not possible. The highest authority upon all questions was Holy Writ, which nobody might question and which the church interpreted. This orientation made acceptable the later Greek preoccupation with formal logic and disdain of matter. Aristotle, that great investigator, was transmuted into an obstacle to further investigation of mundane phenomena. Intellectual acumen achieved triumphs in its chosen fields, but understanding of natural forces was not prominent among them.

The re-birth of science in the sixteenth and seventeenth centuries was brought about by turning from the study of concepts back to the study of nature. The new orientation was characterized by close observation, by the invention of devices to make observation more penetrating and accurate, by purposeful experimentation to simplify the processes observed, by close attention to quantity as well as to quality, by the practical application of mathematics to express the relations observed, by reformulation of concepts to fit the findings, by critical checking of one investigator's work by others, by the cumulation of tested conclusions in old fields of research and by the extension of this mode of inquiry to new fields. Inventing instruments for observing, setting up experiments, measuring and testing brought science again into intimate touch with the practical arts. Investigators took a keen interest in current affairs, sought to profit by the skill of craftsmen and to put what they learned to practical uses. Discoveries were applied not only to the production of goods, but also to navigation, fortification, ballistics and administration. By the close of the seventeenth century the dramatic achievements of "natural philosophy" were leading many to expect an almost limitless advance, and the promotion of science was recognized as a proper object of public policy. Kings lent their patronage to scientific societies. Philanthropists followed the royal precedents by offering prizes for improvements in the arts and later by endowing research.

Of course the public relations of science were not uniformly harmonious in this age of genius. But the celebrated clashes between scientific discoveries and beliefs held by churchmen did not affect many lines of inquiry and did not gravely retard the rising tide of investigation. Not less characteristic of the age than Galileo's troubles were Newton's services to churchly teachings and to the state. Scientific men have lamented that he devoted his later years to arguing the validity of biblical prophecies; they have paid less attention to his work as Master of the Mint. It was adjustments in the relative weight of the guinea and the shilling suggested by Newton that gave England a *de facto* gold standard in the eighteenth century, though Newton did not foresee this result.

An even more striking example of close relations between research and service to mankind is the life of Benjamin Franklin. The foremost American discoverer of his time, he was foremost also in applying and disseminating science to make life more comfortable, more secure, more interesting, more humane. These activities were incidents in the life of a busy printer, editor, politician, postmaster, legislator, colonial agent and diplomat. But while we wonder at the extraordinary versatility of a man who could become both a scientific discoverer and a great states-

man under any conditions, we must remember that in Franklin's day science was still in its "natural philosophy" stage.

With the cumulation of results, science became a more exacting mistress, requiring of her votaries more exclusive attention. But science did not draw away from the material tasks of daily life as it did in Greece. On the contrary, these relations were becoming more intimate, while scientists were learning to speak symbolic dialects less and less intelligible to the public or even to one another. Let me illustrate the seeming paradox by the relations between science and industry.

To most of us the modern age is characterized by technological progress as markedly as by scientific discovery. We think of the two achievements as interdependent. This interdependence was less obvious to Franklin's contemporaries than to us. Theirs was a century of great inventions, but inventions made mostly by men not trained in science. The famous "agricultural improvers" worked by empirical methods. The great textile inventions came from handicraftsmen, one of them a barber. Metcalf, Telford and Macadam, the road builders, were "practical men"; so also was Brindley, the canal builder. Newcommen, "father of the steam-engine," was an ironmonger and blacksmith; his co-worker, Cawley, was a plumber and glazier. The Darbys, who found out how to smelt iron with coke, began as small ironmasters. A few inventors, it is true, tried methodically to discover scientific laws—Smeaton and Watt are eminent examples. Also, some scientists developed inventions out of their discoveries, as Franklin did with the lightning rod, and some set deliberately about the solving of industrial problems—Leblanc developed his process of making soda to win a prize offered by the Paris Academy of Sciences. But these instances were harbingers of a coming day rather than representative products of the eighteenth century.

This new day brought with it a division of labor in the conduct of industry matching the specialization evolving in science. The captains of industry who carried the Industrial Revolution through its youthful phases were often technical experts, business executives and capitalists united in one person. Men of this versatile type are still to be found even in "big business"; but they are becoming as rare as once they were common. For, as technology was elaborated, experts with special training were required to supervise its operations. Engineering became a learned profession—or rather a family of learned professions that multiplied by fission. It won a place in institutions of higher learning beside theology, law and medicine. Inventions continued to come from geniuses with little training, but more and more of them were made to order by experts. Business management meanwhile became so intricate, what with its problems of financing, selling, accounting, selecting personnel, planning investments, and the like, that a good-sized corporation required a staff of men with different skills to do part of the work that an old-fashioned captain of industry had performed for his small establishment. With a considerable lag behind engineering, business administration also raised claims to professional standing and developed schools of its own. As for capital, the requirements of business utilizing modern technology speedily outran the resources of the single enterpriser or partnership. By a series of inventions not less important than those of mechanics, methods were developed for bringing together the savings of countless individuals, rich and poor, by providing types of securities well enough adapted to their several needs to attract funds.

With this double division of labor, in science and industry, the scientist could stick closely to research and feel confident that whatever applications of his discoveries were feasible would be taken in hand by men who knew more about industry than he. The engineer could devote himself as sedulously to technological matters, putting research problems up to laboratory workers and leaving business worries to executives. The latter could get technical experts of many sorts from the schools, and could expect cumulative improvements in technology from the joint labors of scientists and engineers. Investors frequently knew little about the enterprises for which they provided capital; they inclined to rely upon the advice of professional financiers and to protect themselves by spreading risks.

The economic results produced by this unplanned organization of mutually stimulating activities astonished mankind. Industry after industry reorganized its processes time and again to take advantage of the latest engineering applications of scientific discoveries, and new industries kept cropping up. The efficiency of human labor increased greatly, per capita income rose, and hours of labor declined. Higher standards of living and applications of science to the prevention and cure of disease reduced death rates and prolonged the average duration of life. Population grew rapidly in the nations that led the scientific procession, and spread where it would over the earth, dominating, exploiting, sometimes exterminating the non-scientific peoples. Life became ampler if not easier for the beneficiaries of science.

What industry owed science is repaid in many ways. It provided in bewildering variety laboratory equipment more accurate and powerful than that made by hand. It stood ready to construct any new contrivance an investigator designed, and often im-

proved upon the original plans. Fortunes accumulated in business were the source of many scientific endowments. Business corporations granted research funds to universities, and set up research staffs of their own, which were sometimes permitted to work upon fundamental problems.

Governments recognized the social importance of science by making place for an expanding array of scientific courses in public schools and universities, and by undertaking wide-ranging programs of research. In this country, the Federal Government became the largest employer of scientific men. At the time of the Civil War it chartered the Academy of Sciences, and in the World War the National Research Council to advise it upon scientific problems; in 1934 it set up the organization that has developed into the National Resources Planning Board with affiliations covering the full gamut of the sciences.

Finally, the public at large had a share in these great changes. It was the ultimate beneficiary of reductions in costs of production, of increasing per capita output, of new types of consumers' goods, of shorter working hours, of better protection against disease, of free education. And this share was not wholly passive. Wage-earners adapted themselves with less friction than might have been expected to the working conditions imposed by the new technology. If many disliked the impersonal regimentation of the factory and the monotony of machine tending, others delighted in their control over stupendous forces, in the precision of the work they turned out, in the efficiency of the organizations of which they were parts. It is a grave mistake to overlook the enthusiasms evoked by machines, big and little. As recent experience in Russia reminds us, a population that has not become mechanically minded in large measure can not effectively use modern technology. And at home the masses welcomed factory-made goods. In successive generations they thanked engineering and science for illuminating gas, sanitary plumbing, kerosene, telephones, electric wiring, inoculation against epidemic diseases, automobiles, motion pictures and radios. Almost every one participated in scientific discoveries to the modest degree necessary for using these contrivances with some skill. Besides material products, many folk enjoyed what Tennyson called "the fairy tale of science"; their thoughts were pleasurably enlarged by the telescope and microscope. Pasteur, Edison, Mendel, Mme. Curie, Einstein became romantic personalities to tens of thousands, rivaling in popular appeal politicians, business leaders, actors and athletes. Without this eager welcome from society at large, government, business and schools could not have fostered research as they did, and science could not have progressed so rapidly.

It can not be said that these eminently cordial relations between science and the public were consciously engendered by scientific men. Now and then when some scientific hypothesis or procedure was attacked, individual scientists rushed to the defense and sometimes organized protests by scientific bodies. The controversies over what the public called "Darwinism" and "vivisection" are examples. Also scientists answered calls for their services freely and took advantage of opportunities to make their livings on lecture platforms, in schools, governmental bureaus and business enterprises. On appropriate occasions they dilated eloquently upon the service of science to civilization, and investigators with skilful pens and need of royalties wrote popular books. But most of the men who made modern science what it is devoted themselves single-mindedly to research. Their deeds, not their words, won the esteem and raised the hopes of mankind.

In short, this policy of *laissez-faire* worked wonders. Science helped industry, and industry helped science. Even the backward art of agriculture, which faces so many difficulties and uncertainties, was benefiting by research. The dreaded "law of diminishing returns" seemed to be overbalanced by improvements in practice based upon the work of soil chemists, botanists and geneticists. The frightful prospect of overpopulation that Malthus had taught the thoughtful to fear seemed to be dissipated by scientific agriculture and scientific techniques of contra-conception. Best of all, science seemed to have found the secret of illimitable progress. What it had done was merely an earnest of the greater things it would soon do. One discovery led to another so continuously that men began to take for granted a cumulative rise in the standard of living. They moved the Garden of Eden from its traditional place at the beginning of human history into the calculable future, dreaming of a world from which poverty would be banished. If some souls felt oppressed by the materialism of the age, youthful sages arose from the non-scientific peoples to argue, in the words of Hu Shih, that there is more of the spiritual in the scientific effort to control natural forces than in passive resignation to poverty and disease.

II

I doubt that any scientist ever accepted without qualification this idyllic version of the benefits science confers upon mankind. Certainly there were numerous protests from scientific quarters against misuses of the new technology. Geologists and economists warned against the rapid depletion of mineral deposits. Chemists feared for the nitrogen content of the soil. Geographers and meteorologists protested that wholesale cutting of forests and the plowing of

grass lands produced deserts. Biologists lamented the extinction of animal species and anthropologists the callous stamping out of simpler cultures. Social scientists found much amiss within the countries that were most progressive. Urban and rural slums persisted as centers of disease and crime. The need of securing capital to utilize the new technology put control over it into the hands of the propertied classes. Labor was often grievously exploited. Huge fixed investments that could be used for only one purpose made competition destructive. The obvious escape from these hazards was to form monopolistic combinations. That was pleasant for the monopolists, but not for other business men or for consumers. Besides the obvious dangers of exploitation, many feared that the great combinations might purposely slow down technological advance because it threatened rapid obsolescence of their equipment. Business did not manage even its own interests properly, for every few years it generated a crisis and depression in which it suffered along with the whole community. And the international relations of the scientifically advanced peoples showed at his worst "the old savage in the new civilization." Demonstrations of the economic advantages of free trade no more stopped the imposition of protective tariffs than demonstrations of the horrors of war kept peace. Militant nationalism seemed to be spreading and growing more passionate. An appreciable fraction of scientific energy was devoted to contriving weapons of destruction. Thus against the glowing picture of science as a benefactor of mankind could be set a dark picture of science putting more power into the hands of certain individuals, classes, nations, generations, giving them a differential advantage over others which they exploited according to their several natures.

Though some of the Jeremiads I have been recalling belong to an earlier time, they did not produce a profound effect upon the public relations of science until recently. The ills complained of could be regarded as "growing pains." They were thought of as social "problems," which should be dealt with by arousing public opinion in a campaign of education that would lead to remedial legislation. Problems that could not be solved by this time-honored method would yield presumably to the slower processes of general enlightenment.

This optimistic attitude was particularly characteristic of democratic nations. It assumed tacitly that experts could devise whatever "reforms" were needed, and that the majority of voters were intelligent enough to understand and well disposed enough to support desirable changes. Science had a stellar role in this program for remedying the ills incidental to progress. It did not claim knowledge of good and evil; but it enabled men to make their value judgments more intelligent by tracing the consequences of actions. Many people were devoting their energies to the study of social problems; they spoke optimistically of their subjects as social "sciences." It seemed not too much to hope that science might presently begin to guide social practice in somewhat the same fashion as it guided practice in industry and medicine.

A man might be skeptical of the nascent social sciences; but he could scarcely deny that the leading scientific nations managed to readjust their economic, political and social institutions when the new technology produced results they deemed bad. True, the readjustments were usually made by attacking one evil at a time, without due consideration of indirect consequences, which were often unfortunate in good part, and sometimes canceled the gains. Also the processes of reform lagged so far behind the changes produced by applications of scientific discoveries that new troubles began and new social adjustments were needed before the preceding reforms had been perfected. Despite all this, the scientific nations believed themselves to be evolving a social order adapted to the times—one that enabled them to grasp ever more fully the ever larger benefits scientific progress was bestowing upon mankind. I question whether history can show another period in which human hopes soared so high as in the closing decades of the century between Waterloo and the first World War.

III

That the public relations of science have recently become disturbing both to the public and to scientists is due, not to any change in the character of science or the behavior of scientists. but to changes in social conditions. While most people approved on the whole the applications of science before 1914, they have come to dislike many of the effects produced by later applications. To be specific: when scientific improvements in one industry after another threw men out of work in earlier decades, the victims might suffer in silence or protest riotously and perhaps smash machines. But the public at large was not deeply concerned over their sufferings; it repressed disorder, expected the displaced men to find new jobs for themselves, and blessed science for reducing costs of production. Now that a larger part of the public suffers from loss of work or obsolescence of investments, science is blamed for technological unemployment. When the modern arts of communication were used to facilitate the political processes of democratic nations, they were extolled on all sides. Now that these arts, further improved, are controlled in some countries by autocratic governments and used to suppress opposition, many good people treat science as the culprit. When the scientific nations used their

superior arms against backward peoples, only a few sensitive souls were wrathful over the unfairness or iniquity of the procedure. Most people felt that science was good when it gave them a decisive advantage over those they wished to "civilize." Now that these same nations are threatened by still more terrible weapons in the hands of their peers, their moral horror is sincere, and they wish scientific warfare back to the pit from which it was digged.

This shift in attitude toward science as one happens to benefit or suffer from its applications is doubtless a mark of human frailty, but it is one at which scientists should not cavil without recalling a similar frailty of their own. Now that we are on the defensive, we discover that science is neither good nor bad in itself, but is merely an instrument that can be put to good or bad uses, and that the blame for bad uses should be visited upon those responsible for them. But when science was being lauded for good works, who among us argued that the credit belonged, not to science, but to those who used it for the benefit of mankind?

We made this discovery when difficulties forced us to think more carefully about the place of science in society. Well as the old policy of *laissez-faire* in public relations worked for a time, it had encouraged in us an indolent complacency foreign to the critical spirit of inquiry. We may not enjoy the shocks that have aroused us any more than an investigator rejoices over facts that disprove an elegant hypothesis; but we must face the situation and see what we can do to mend it. Every one concerned with the future of science or of mankind bears a share in the responsibility for trying to understand the present situation, and to decide what action, if any, is called for. It is not likely that a satisfactory solution can be produced in short order, for the problem is one of numerous variables in shifting combinations. But I venture to suggest an obvious proposition that seems to me of controlling importance, and to point out certain corollaries that should guide both our attempts to understand the public relations of science and our future policy concerning them.

IV

The fundamental proposition is that scientific research is a social process as much as business, political or religious activities are, and as such is interwoven with all other social processes, influencing them and being influenced by them.

My historical sketch of the public relations of science supports this view. But let me borrow two illustrations from thoughtful physicists. David L. Watson has shown that social institutions impose their pattern upon research, putting a premium upon conventional inquiries and obstructing originality. Like other social activities requiring close cooperation, research gets organized, organizations become bureaucratic, bureaucrats may have routine efficiencies, but originality of thought and cordial welcome to originality in others are not conspicuous among them. Watson compiles a formidable list of instances in which scientific organizations have been slow to recognize fundamental discoveries, and he makes his point more uncomfortable by naming certain rather odd contemporaries who may be doing work more important than the men to whom we award medals.[2]

In a way that should come close home to every investigator, P. W. Bridgman has pictured the intellectual struggles a scientist must undergo if he strives seriously to live "an intelligently well-ordered life." Accustomed to subject his concepts in physics to operational tests, Bridgman tried to treat with similar rigor the concepts that count most in social intercourse. The results were disconcerting.

> Not one of our social institutions (he found) rests on the secure foundation that we so easily assume when we refute the skeptic or instruct our young. Never has any institution been justified in terms that anyone capable of close thinking could accept without stultification. Yet if ever the tragic need for close thinking and intelligent convictions on social questions was obvious it is at the present.

This loose thinking that characterizes social intercourse introduces confusion into the lives of all, though the confusion may be recognized only by those who try to live intelligently. For every one derives the words in which he thinks from society. They bring into mental processes all sorts of implications inherited from the past that will not bear analysis, and from which one can free oneself only by laborious analysis of the sort that has made the exact language of physics differ from the ambiguous language of everyday life.[3]

Scientific research, then, is one among many social activities carried on by the peoples of our culture. Like all such processes, it is carried on by men who learn in childhood languages ill suited to close thinking; by men who wish to eat, to make love, to win approval as well as to know; by men who are reared in an environment of emotional likes and dislikes; by men who become so absorbed in their technical tasks that they have little energy to criticize the non-scientific parts of their own make-up. And these scientific men form a tiny fraction of their communities. So far as they succeed in emancipating themselves from the misconceptions and prejudices pre-

[2] David L. Watson, "Scientists are Human," London, 1938.

[3] P. W. Bridgman, "The Intelligent Individual and Society," New York, 1938.

vailing in their social groups, they become by virtue of their partial emancipation queer creatures whose judgment most people mistrust outside of their specialties. Both the temperament that inclined them to research and the habits they form in research tend to make them awkward, ineffective, reluctant in appealing to the emotions that are so potent in influencing men. It is difficult to see how a few scattered individuals, each accusomed to think for himself and to be critical even of his fellow inquirers, can guide public opinion except by slow educational processes. In the long run their thinking may rule the world, just because it serves the purposes of mankind better than the traditional thinking it gradually replaces. But in the short run, others take of scientific discoveries only the parts that have an immediate application, and put these parts to such uses as they see fit—uses that serve whatever aims these others pursue. The prompt and potent influence of science upon society comes from these uses, good and bad, which scientists control only in small part.

Even in democratic countries, then, scientific men find it hard to bridge the gulf between their attitudes and those of the general public. In autocratic states the governments might give scientists fuller opportunities to direct public policies than they enjoy in democracies. But the autocratic states known to us are not built on that model. They are avid for science, to be sure, but only for science that is an uncritical servitor of ends the rulers determine. As between the difficult public relations confronting them in democracies and the shackling of free inquiry confronting them in autocracies, scientists can not hesitate. Theirs is a world of intellectual freedom, not perfect, alas, but the freest world the mind of man has yet created, and to let any authority under any pretense prescribe what conclusions they shall accept as scientific is to stultify the spirit of science.

V

What, then, can scientists do to improve their public relations in communities where they are relatively free?

As I see the situation, they have two sets of opportunities and responsibilities: first, their opportunities and responsibilities as citizens; second, their opportunities and responsibilities as investigators.

It must be admitted that to many scientific men the performance of civic duties is an unwelcome interruption to their research work. Some brilliant investigators are temperamentally unfitted to share in the tumultuous processes by which a democracy reaches its decisions. Among the great discoverers of the past there have been cynics who despised the "common herd," recluses who could scarcely endure social contacts, geniuses so erratic that their judgments upon practical affairs seemed crazy, rationalizers who urged the insignificance of one citizen among millions as an excuse for shirking responsibilities. Presumably representatives of these types exist among our scientific contemporaries; but I know no ground for supposing that they form a larger proportion of the persons listed in Dr. Cattell's "American Men of Science" than of those listed in "Who's Who in America." A goodly majority of scientific men have normally balanced personalities and are competent citizens. They can be counted upon to take their civic responsibilities as conscientiously on the average as any other group, and to act with as much commonsense.

What scientific men can do as citizens is like what other intelligent men can do. If democracy is to work well, many people must form considered judgments upon a wide variety of problems. In forming a considered judgment on a given issue, what experts have to say should be taken into account. Who these experts are depends upon the character of the issue; more often than not contributions are needed from several kinds of specialists. All the many species of the genus scientist belong at one time or another in the list of desirable technical advisers; so also do lawyers, business organizers, labor leaders, social workers, educators, civil servants, politicians, and so on. When matters within the competence of some group of scientists are involved, they should contribute what they know, whether formally invited to do so or not. To make their advice effective they should welcome help from people more skilled than themselves in the arts of popular presentation. On matters concerning which a scientist has no special knowledge, he should listen to others and form the best judgment he can from what they advise. To an individual this task of sifting and weighing different opinions is time-consuming and difficult. On complicated issues organization is needed to bring into focus all the intelligence available in the community. Hence, one of the civic duties incumbent upon all scientific men in common with other citizens is to support vigorously but critically the nascent movement toward organizing all the intelligence we possess for constructive study of social problems before they become pressing emergencies that have to be dealt with in a hurry that allows no time for careful thinking.

The outside limits of what scientists can accomplish as citizens are set by their ignorance. Not merely does no individual have more than a tiny fraction of the knowledge that is needed; all the scientists of the country put together do not know enough to solve many of the problems that a democracy faces. In addition to the responsibilities they share with all other citizens, scientific men have the special duty of

trying to increase the kind of knowledge required to deal intelligently with public problems. Their opportunities and responsibilities as citizens merge into their opportunities and responsibilities as investigators.

From the social view-point, the most urgent item in the unfinished business of science is to increase knowledge of human behavior. If we had keener insight into individual psychology, we might not be able to alter fundamental drives, but we might be able to direct them into beneficent channels. Preaching righteousness doubtless prevents men from being as bestial as they might otherwise become. Appeals to reason prevent them from making as many errors as they otherwise might. But the moralist and the rationalist admit that the results of their efforts are grievously disappointing. Scientific men with any gift of self-analysis realize that they have their own shares of selfishness and animosities. To subdue traits in oneself is hard enough to give an inkling of the difficulty of controlling them in society at large. Perhaps, and perhaps is all we can say, if we can come to a clearer understanding of how we behave, we can learn how to condition men so that their energies will go less into making one another miserable.

One of the things we have learned about individual behavior is that it is influenced greatly by social environment. In John Dewey's phrase, "all psychology is social psychology." Improving knowledge of social organization and its working is therefore part and parcel of the urgent task of learning how men behave. Though we may believe ourselves citizens of the most fortunate nation in the world, we have no more reason for complacency about the way in which our social organization works than for complacency about individual behavior. For example, our economic organization does not permit us to buy from one another as much wealth as our workers are able and eager to produce. Even in the best of years we fail to provide a national income large enough to give American families on the average what experts on household economics hold to be a standard of living adequate to maintain efficiency. In bad years this inadequate income falls off by a fifth or a sixth; in the very worst years by 40 per cent. or more. All this is true of our industrial equipment and practice as they stand. Proud as they are of our technological progress, engineers know that much of our equipment and many of our methods are far behind the times. We fail to make full use of knowledge that technological applications of scientific discoveries have put at our disposal. I might develop the shortcomings of our economic organization at great length, and then go on to exploit the weaknesses of our political and social institutions. It is needless to do so; for every candid and intelligent citizen can point out defects, however convinced he may be that, with all its faults, the American scheme of institutions is the best in the world. If scientists can do more than other intelligent citizens toward improving social organization, their contribution will consist in raising knowledge of social practice.

We all know that the social sciences lag far behind the natural sciences. That is because they deal with phenomena more complicated, more variable and less susceptible of experimental manipulation. Since investigators can not experiment at will upon social groups, they can not effectively apply to their problems the methods that have made the laboratory sciences strong. Max Planck once told J. M. Keynes that in early life he thought of studying economics, but found it too difficult.[4] Of course economic theory as we have it to-day is far easier to master than physical theory. But Planck was a true scientist, one who wished to gain knowledge that accounted for actual phenomena. He had learned enough to realize that it is far harder to get such knowledge of economic than of physical processes.

Yet the case of economics and its sister sciences is not hopeless. The rapid growth of statistics is providing mass observations upon social behavior of many kinds; the equally rapid growth of statistical technique enables us to learn more from a given array of data than our predecessors could. These materials and methods are making it possible to measure many social factors, some rather accurately, some roughly. Uniformities appear not only in averages but also in the way in which individual items are distributed about their means. Statements in terms of probability can be substituted for vague statements about the effect a certain cause "tends" to produce. True, work on this observational basis encounters many difficulties. It is limited by the variety, extent and accuracy of reliable data upon human behavior. It is laborious, slow and expensive. In presenting his work a realistic investigator begins with a critique of his data and methods, he ends by setting forth the probable errors and limitations of his results, and the road from the beginning to the end may be long. Instead of definitive conclusions he thinks others should accept, he presents tentative approximations he expects others to improve. The work has not even the advantage of calling for less hard thinking than speculative theorizing; for the relations among the variables in the problem are seldom manifest of themselves. All that can be claimed for this type of work is that it deals with actual experience, that its results stand or fall by the test of conformity to fact, and that it grows cumulatively after the fashion of the

[4] "Memorials of Alfred Marshall," edited by A. C. Pigou, London, 1925, p. 25, note.

observational sciences. But that is enough to give mankind strong reason for following this lead in seeking the knowledge required to improve social organization.

I do not imply that the social sciences can rapidly become such assured guides to social progress as the natural sciences are to technology. Because of difficulties inhering in their subject-matter, the social sciences will continue indefinitely to lag behind the natural sciences in precision and reliability. For a long time to come we shall have to form our opinions on many social issues in the light of common sense rather than of science. Knowledge of past experience should prove helpful in this uncertain process, and advice from specialists who have studied this experience should be sought. But wise technical advisers in these difficult matters will not pretend to certitude. As citizens we shall do well to suspect the intelligence, the candor or the disinterestedness of those who promise sure cures for social ills.

Scientific men are wont to face facts, whether these facts conform to their wishes or not. Most of them are sufficiently emancipated from conventional thinking to look critically upon social institutions. They contrast the society of to-day with its poverty in the midst of plenty, its class, racial and international animosities, its puerile aims and its destructive methods, to a society they can imagine living in security and comfort, using its increasing knowledge to provide a finer life for all mankind. This contrast should not be accepted in a spirit of resignation. It is a call to action. But scientific men will not be true to their own standards, they will not render to society the largest service of which they are capable, if they let their actions be guided by their feelings. No current discouragement should blind us to the great strides in human welfare made since science assumed its modern form; no fit of impatience over delays and relapses should make us forget that knowledge is won step by step, through the toilsome efforts of thousands of men. To jump this work with its numberless failures and its gradually cumulating successes, expecting to land in Utopia, is to give up faith in science for faith in magic. Men who take scientific methods seriously as the best hope of floundering mankind will seek to apply them just as critically and remorselessly in their social as in their physical thinking.

But science can not flourish in the future and yield the fruits for which we hope unless freedom of thought prevails. That is a condition we have been inclined to take for granted as part of the heritage our predecessors won. Now we realize that what they fought to win we must fight to maintain. The investigator's right to follow truth wherever it led was part of the common man's right to freedom of conscience and freedom of speech. These rights were established by political struggles and embodied in political institutions. The democratic way of life and the scientific way of thinking grew up together, each nourishing the other. If one now fails the other will falter. Where democracy is suppressed to-day science is fettered; for autocracy can not brook disinterested criticism of its dogmas or its practices. Freedom of scientific work in the years to come can be guaranteed only by preserving the institutions that secure freedom to all citizens. Perhaps scientific men have more at stake than any other social group in the struggle to maintain democracy.

To this struggle they can make a crucial contribution. The fate of free societies hangs upon the wisdom or folly of mass decisions. The gravest dangers to democracy come from within, not from without. They are ignorance and propaganda that turns ignorance to its uses. The best way of dispelling ignorance is by diffusing knowledge. The most effective defence against meretricious propaganda is critical inquiry. John Dewey is warranted in saying that "the future of democracy is allied with spread of the scientific attitude."[5] To foster this attitude among their fellow citizens by all means within their power is a duty incumbent upon us who cherish science. As teachers in schools and colleges we can help thousands to develop respect for evidence. As citizens we can be brave opponents of prejudice and hysteria. We can promote general understanding of the methods and results of science through our own writings or those of allies more skilled in popular exposition. These things we should do, not as high priests assured that they are always right, but as workers who have learned a method of treating problems that wins cumulative successes, and who would like to share that method with others.

OBITUARY

FREDERICK ADAMS WOODS

FREDERICK ADAMS WOODS was born at Boston, on January 29, 1873, and died on November 5, 1939, in Rome, Italy. His father was Solomon Adams Woods, who, born in Farmington, Maine, 1827, came to Boston about 1847 and became a successful manufacturer of wood-working machinery. Frederick Adams Woods's mother was Sarah C. Watts. She was fond of study. Her father was a seafaring man whose later life was spent in Boston devoted to study, especially of mathematics. Frederick's career was largely determined by

[5] "Freedom and Culture," New York, 1939, p. 148.