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Social Aspects of Science

Preliminary Report of AAAS Interim Committee

The council of the American Association for the Advancement of Science, at its 1955 meeting, resolved to establish an "Interim Committee on the Social Aspects of Science." During the past year this committee has made a preliminary study of the present state of science in the United States and its relation to social forces and issues. The committee found that even a cursory examination of this question leads to a serious conclusion: that there is an impending crisis in the relationships between science and American society. This crisis is being generated by a basic disparity. At a time when decisive economic, political, and social processes have become profoundly dependent on science, the discipline has failed to attain its appropriate place in the management of public affairs.

The committee believes that this question demands the most urgent attention of the AAAS and of scientists generally. The present interim report is not intended as a complete consideration of the many interrelated problems encompassed by the area which the committee has studied. Rather, the report represents a sampling of some of the issues which the committee has found to serve as useful points of departure in developing an analysis of the situation. Because of the importance of this matter, the committee believes that any decision on the manner in which the AAAS can best deal with it should be based on extended and broadly conducted discussion among natural and social scientists and other interested persons. The report which follows is intended as one means of initiating this discussion.

Such an undertaking comes at an opportune time. We are at the start of a period in which science holds the promise of making unprecedented improvements in the condition of human life. Any action taken now to assist the orderly growth and beneficial use of science will be of lasting significance.

New Scientific Revolution

A cursory examination shows that society has become far more dependent on science than ever before for the following reasons.

Accelerated growth of scientific activity. The volume of scientific research and development conducted in this country has been increasing at an astonishing rate. In 1930, expenditures for science were estimated at $166 million; in 1953, the amount was more than $5 billion. Allowing for the change in the value of the dollar, this represents approximately a 15-fold increase in research expenditures over the 23-year period. The number of active scientists in the United States in 1930 was 46,000; the present number is probably about 250,000. All estimates of future needs for scientific research and personnel indicate that this growth will continue at an accelerated pace. This rate of growth sets scientific activity apart as the second most rapidly expanding sector of our social structure, military activities being first.

Increased use of scientific knowledge. It is characteristic of the present era that the previously formidable gap between scientific knowledge and its application to practical problems has become considerably reduced. It is now commonplace that calculations based on physical theory move quickly from the scientist's laboratory across the engineer's drafting board and on to actual industrial production. Since 1940 we have experienced a series of classic examples of almost immediate conversion of a scientific advance to a process of large practical impact upon society: antibiotics, synthetic polymers, nuclear energy, transistor electronics, microwave techniques, electronic computers. The greatly narrowed gap between laboratory and factory results from a distinctively new role of research in industry. Scientific investigations were previously regarded by industry as a kind of exotic garden to be cultivated in the hope of producing an occasional rare fruit. In contrast, research has now become a deliberate instrument of industrial development; scientific investigations are consciously undertaken as a means of achieving desired economic gains or, as in several notable industrial laboratories, for the purpose of contributing to our fund of basic scientific knowledge.

Recent advances in science have also created completely new industries. Four major industries—chemical, electronic, nuclear energy, and pharmaceutical—represent direct extensions of laboratory experience to an industrial scale. This type of direct transformation of scientific experience to industrial operation is probably unique in human history. Earlier industrial developments were based more on empirical experience than on laboratory science.

Social Position of Science

Science is but one sector of our culture. It is one of the institutions of society, and to a considerable degree society itself governs the development of science. In the present situation, social forces influence the development of science in the following key ways.

Social demand for technologic advances. From the evidence already cited it is clear that there is a strong social demand for at least some kinds of scientific progress. The fact that industry has made unprecedented investments in research is practical evidence that this type of scientific work is seen as a desirable activity by industrial managers. Government scientific activity, which

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perhaps reflects a wider range of social forces, has also been very intense in the past 20 years. Accelerated support for scientific research is evident from the increased scale of military research, the growing activities of the National Science Foundation, the greatly increased support for medical research by the National Institutes of Health, and the increasing share of philanthropic funds from private agencies now devoted to research on health and social problems. The following generalizations may be made concerning the distribution of the enhanced research support now enjoyed by American science.

1) The major part of research support goes into applied research and development rather than into basic science. In industrial research, the ratio is about 97/3; in universities, about 50/50; in federal agencies (including support for research done elsewhere) about 90/10.

2) Support is heavily slanted toward physical sciences. In 1954, federal research support was divided as follows: physical sciences, 87 percent; biological sciences, 11 percent; social sciences, 2 percent. Industrial research is at least as heavily weighted in this direction.

3) At present a very large part of our total research activities are for military purposes. Of the estimated federal expenditures for research in 1957 ($2.5 billion), about 84 percent is earmarked for matters related to national security.

4) Colleges and universities, which are the site of much of our basic research activities, have become dependent on federal funds for the greater portion of their research support (60 to 70 percent in 1954).

Some of the effects of these factors upon the character of scientific research are discussed in the section on "Internal situation in science."

Public interest in science. There are indications that the public interest in science is not commensurate with the important role of science in society.

1) Shortage of scientific personnel: We face a major crisis with respect to present and future shortages of scientific personnel. In effect, this means that the social environment in the United States does not elicit a maximum interest in science on the part of those individuals who have the capability of doing scientific work, or that our social organization does not permit them to receive the necessary training. This problem is closely connected with the more general question of the present state of public education in the United States. The content of public education has been subjected to a good deal of criticism recently, especially with regard to science and mathematics. Many scientists feel that an official state requirement for graduation from high school which calls for 1 year of "general" mathematics and for 1 year of "general" science cannot be regarded as proper recognition of the importance of science.

2) Attitudes toward scientific work: To some degree the foregoing difficulties reflect a broader problem—that is, a traditional disregard for abstract thinking. More than a century ago De Tocqueville observed, "Hardly anyone in the United States devotes himself to the theoretical and abstract portion of human knowledge." He said that the immediately practical aspects of life were, however, fully appreciated. The same generalization appears to be true today. So-called "practical" men of public affairs and business frequently disregard the advice of scientists and prefer instead to rely on "common sense," but the latter is often construed to mean what Einstein has called "a deposit of prejudices laid down in the mind prior to the age of 18." This problem, particularly as it relates to a lack of interest in scientific careers, has attracted considerable attention of late. Recent surveys indicate that the general attitude exemplified by popular epithets such as "eggheads" and "longhairs" is well rooted in the opinions of young people.

3) Science in the public press and other media: By all standards, science receives an unduly small share of the budget of newspaper space or broadcasting time. The number of books and magazines devoted to disseminating public information about science is correspondingly small. The immediate reasons for this state of affairs are manifold. It is clear, however, that the situation reflects a rather low level of interest in science on the part of the public, or, more probably, of those who attempt to judge the public mind for purposes of directing the media of information.

Internal Situation of Science

How has its recently accelerated rate of growth and the general nature of the social influences upon it affected the character of American science? Some brief and approximate answers may be made.

Unbalanced growth. The growth of our scientific organization has not been an orderly process. Growth has been based less on internal needs of science than on the interest of external agencies in possible practical results. In a sense, the speed and direction of the development of science has been determined by the users of science rather than the practitioners of science. Agencies which use scientific knowledge (for example, industrial management, military establishments, medical agencies) have undertaken to encourage, and pay for, scientific research of a sort which seems to promise information that might be useful to their own specific purposes. This disproportionate growth of the physical sciences as compared with biological and social sciences to some degree reflects the interests and superior financial resources of the industrial and military agencies that support science.

The effects of this unbalanced development are already being felt. Generally speaking, we sometimes find ourselves embarking upon new ventures, based on advances in chemistry and physics, before we are adequately informed about their consequences on life or on social processes. Some of the resultant difficulties which we have already made for ourselves are described in the section on "Major social issues of scientific origin: signs of trouble."

It should be recalled that this unbalanced growth takes place within the framework of a shortage of personnel. This situation has very naturally given rise to a somewhat disorganized competition for students, which further accentuates the disparate pattern of development of the various sciences.

Inadequate progress in basic research. It is well known that the creative source of all technologic advance is the free inquiry into natural phenomena that we call basic, or "pure," science. However, as has already been indicated, the great bulk of our present research activities represent the development of practical applications of the knowledge generated by previous advances in pure science. It has been pointed out repeatedly that many of our current technologic advances are based on the application of accumulated basic knowledge which is perhaps 20 to 30 years old. The progress of basic science does not appear to be keeping pace with the development of applied science. Some observers even feel that there has been an absolute decline in the amount of highly creative research of the type that leads to major advances in our knowledge of nature. They point out that our present understanding of the structure of atoms and molecules and of the behavior of living cells goes back to great illuminating propositions that are 25 years or more old.

Difficulties in scientific communication. New information is the major goal of scientific research, and communication of information is vital for all scientific progress. However, the rapid, rather disordered growth of science has placed a severe strain on the channels of scientific communication.

1) Communication among the divisions of science: The problem of adequate dissemination of the results of current research has become a matter of great concern. The growth of our research establishment and the resulting

increase in the numbers of scientific communications have made the problem of "keeping up with the literature" quite serious. It is now widely recognized by scientists that the existing system of publication and distribution does not fill their needs. Published articles and monographs have not kept up with the current knowledge in many fields. The number of journals is insufficient (publication delays of 1 year are common) and methods of abstracting, indexing, and reviewing are inadequate. It is becoming rapidly more difficult for scientists to find out what their colleagues know. The situation is particularly bad with respect to articles printed in foreign languages (Russian, especially) which investigators are too frequently incapable of reading. Some observers have already urged the establishment of scientific information centers from which subscribers could receive transmitted reproductions of teletyped abstracts obtained by electronic scanning devices. Such centers would require government investment of about $150 million. That proposals of this magnitude are under current discussion is an indication of the severity of this problem.

Proper communication among scientists is not, however, merely a matter of developing proper recording, cataloging, and searching devices. Face-to-face meetings, which bridge the barriers of specialization, are an obvious necessity for the ordered growth of human knowledge. There is a widespread feeling among scientists that scientific meetings which bring together investigators from different fields of science are a necessity. But, with some distinguished exceptions, such meetings have been difficult to establish thus far.

2) Imposed restrictions of free communication: Although government support has been a major source of recent scientific growth, it has been accompanied by influences which are in some respects inimical to the basic needs of science. Complete freedom of communication, regardless of national boundaries, is an essential aspect of science; nevertheless, along with government support American science has been burdened with practices that restrict the free flow of information. The interchange of scientific information is sometimes restricted unduly by the overclassification of data that affect national security. It must be acknowledged that at certain times, and with certain types of data, restriction of exchange of information is necessary, so long as scientific progress continues to have military activity as one of its chief values. The immediate problem is to limit such restrictions to a minimal area. The ultimate problem is to free society as a whole and thereby science itself from the tyranny of war.

Not all artificially imposed restrictions on communication result from government requirements. There is an understandable tendency on the part of industry to protect its investment in research by restricting distribution of its results. As a greater share of research is taken on by industry, especially in those areas where expensive, complex operations are involved, this problem will become of greater significance. It is ironical to note that a recent Conference on the Practical Utilization of Recorded Knowledge—Present and Future (at Western Reserve University, January 1956), which devoted a good deal of attention to the problem of improved dissemination of knowledge, found it necessary to hold part of its deliberations behind closed doors and to refrain from publicizing the full record of these "confidential" sessions [(*Am. Scientist* (April 1956)].

Unrestricted communication is but one facet of the free intellectual environment that is as important to scientific creativity as it is to all other fields of human endeavor. If society is to benefit broadly and effectively from the efforts of modern science, and if science in turn is to be enriched by contributions from other fields, the social order must provide the greatest possible intellectual, social, and personal freedom for scientist and nonscientist alike at every level of the social structure.

Major Social Issues of Scientific Origin: Signs of Trouble

How well have we solved those social issues which are most closely related to scientific or technologic knowledge? Most of our successes are self-evident. Scientific knowledge is being applied to the development of a new industrial system capable of greatly increasing, in both quantity and quality, the total wealth of man. We are creating a remarkable establishment for medical and related research, which has given us mastery of many human ills and has prolonged the span of life. Nevertheless, scientific problems which influence social processes have become an arena of serious difficulties. In some situations our enhanced ability to control nature has gone awry and threatens serious trouble. Some examples follow.

Radiation dangers. It is hardly necessary to point out at this time that the difficulties created by the dispersion of radioactive materials from nuclear weapons have caused considerable concern in this country and throughout the world. Regardless of one's attitude toward the necessity of setting off nuclear explosions for testing purposes, there is considerable evidence that this aspect of human control over nature is a potential danger to life. The recent controversy over the immediate significance of this problem shows that we have not yet developed methods for the orderly determination of the facts, in an area in which such facts may influence the health of the whole population of the earth.

Food additives. The enormous growth of industry based on organic synthesis, coupled with the already mentioned tendency toward rapid exploitation of sci-

Resolution adopted by the Council of the American Association for the Advancement of Science at its 1956 meeting in New York

WHEREAS one of the purposes of the AAAS is "to improve the effectiveness of science in the promotion of human welfare, and to increase public understanding and appreciation of the importance and promise of the methods of science in human progress," and

WHEREAS the present rapid advance of science is accompanied by social problems of unprecedented magnitude that affect human welfare;

THEREFORE BE IT RESOLVED that in recognition of the responsibility of scientists to participate in deliberations regarding the use made of new scientific knowledge, the Council of the AAAS authorizes the president to continue the work of this committee by appointing an enlarged group for the purpose of defining the problems, assembling the relevant facts, and suggesting a practical program, to be submitted to the AAAS board of directors, to implement the objectives of the AAAS in this regard.

entific knowledge, has resulted in a great increase in the number of man-made compounds now used in foods or otherwise ingested or absorbed by human beings. The period of use of many of these substances has been rather short, and possible undesirable long-range biological effects have not yet had time to appear. Laboratory methods for studying delayed biological effects such as carcinogenicity are unfortunately difficult to manage and equivocal in interpretation. Consequently, the establishment of certification procedures which might assure the public that a given additive is harmless is a difficult matter which has been the subject of considerable discussion and controversy. Nevertheless, additives are in use, and the problem of making a reasonable determination of their safety must be faced.

A parallel situation exists in connection with the health hazards that arise from the dissemination of fumes, smogs, and dusts by industrial plants and from automotive and other combustion processes. The harmful biological effects of these agents usually appear a long time after the commercial usefulness of the process is established and large-scale operations are in effect. By then remedial procedures are very difficult to carry out.

In these cases the use of substances resulting from scientific advance has already outstripped the base provided by our scientific knowledge. Information on the biological effects of a new substance is acquired at a very much slower pace than the rate at which new substances are made or put into use. It is probably inevitable that biological research will move more slowly than either chemistry or physics, but it should be expected, therefore, that we would put correspondingly more effort into research on biological phenomena. The opposite is the case. Less than about 10 percent of our total research expenditure goes into biology and medicine.

Natural resources. The natural resources contained in the crust of the earth comprise the major source of our wealth, and it is a matter of concern that they be properly used. The natural laws which regulate the character and behavior of these resources lie within the domain of the various sciences. However, social decisions actually control what is done with our resources. It has been pointed out by Paul B. Sears that these decisions are rarely in the hands of scientists. Under these circumstances large-scale changes in our natural resources have occurred without proper consideration for the consequences which might be expected from a knowledge of natural laws.

An illuminating example cited by Sears is the recent flood disaster in New England. He points out that the widespread damage caused by these floods was a direct consequence of the unplanned crowding of housing areas into the river flood-plains. This was a failure to recognize and act upon physical events easily foreseeable from a relatively simple knowledge of the landscape. The declining water-table caused by irrigation practices illustrates a similar disregard for natural laws. In these and more complex instances, the harmful outcomes of the given practice can be predicted by appropriate technical analysis.

These examples show that social factors condition the use to which scientific knowledge is put. Perhaps the most striking example of this phenomenon is modern warfare, which represents a social decision to use the power of scientific knowledge for purposes of destruction and death.

Some Conclusions

The present state of science and its relation to the social structure of which it is a part are characterized by the following general features.

1) We are witnessing an unprecedented growth in the scale and intensity of scientific work. Research has placed in human hands the power to influence the life of every person in every part of the earth.

2) This growth has been stimulated by an intense demand for the practical products of research, especially for military and industrial use. Agencies which use the products of research are willing to provide financial support and other forms of encouragement for science but show a natural tendency to favor those fields and aspects of science which most nearly relate to their needs.

3) The public interest in, and understanding of, science is not commensurate with the importance that science has attained in our social structure. It cannot be said that society provides good conditions for the proper growth of science. The effort to explain the nature of science to the public is slight compared with the public attention now given to other less consequential areas of human activity. Interest in science as a career is so restricted that a serious and worsening personnel situation has arisen.

4) For reasons such as those just cited, science is experiencing a period of rapid but rather unbalanced growth. Basic research, which is the ultimate source of the practical results so much in demand, is poorly supported and, in the view of some observers, lacks vigor and quality. Areas more remotely connected with industrial and military applications, such as biology and the social sciences, are also not being adequately supported. The present period of rapid, unplanned growth in research activities is precipitating critical difficulties in connection with the dissemination and analysis of scientific information.

5) The growth of science and the great enhancement of the degree of control which we now exert over nature have given rise to new social practices, of great scope and influence, which make use of new scientific knowledge. While this advance of science has greatly improved the condition of human life, it has also generated new hazards of unprecedented magnitude. These include the dangers to life from widely disseminated radiation, the burden of man-made chemicals, fumes, and smogs of unknown biological effect which we now absorb, large-scale deterioration of our natural resources, and the potential of totally destructive war. The determination that scientific knowledge is to be used for human good or for purposes of destruction is in the control of social agencies. For such decisions, these agencies and ultimately the people themselves must be aware of the facts and the probable consequences of action. Here scientists can play a decisive role: they can bring the facts and their estimates of the result of proposed actions before the people.

Need for Action: the Role of the Organizations of Science

This appears to be a critical time for review of the general state of science and its relation to society. We are now in the midst of a new and unprecedented scientific revolution which promises to bring about profound changes in the condition of human life. The forces and processes now coming under human control are beginning to match in size and intensity those of nature itself, and our total environment is now subject to human influence. In this situation it becomes imperative to determine that these new powers shall be used for the maximum human good, for, if the benefits to be derived from them are great, the possibility of harm is correspondingly serious.

As scientists we are particularly concerned with determining how we should meet this situation, both as individuals and through our organizations. In marked contrast to other associations, scientific societies seldom consider the social and economic position of their group. Action taken on social problems with a scientific or technologic base are sporadic and usually forced. Yet the democratic system is operated to a considerable extent under stimulus from groups, each representing the views and interests of its members.

Business and labor are not backward in presenting their opinions on social questions that affect them. They make sure that in the final decision their views have been considered. There are many who think that the viewpoint of scientists should also be stated publicly. In fact, if others express their opinions and scientists do not, a distorted picture will be presented, a picture in which the importance of science will be lacking and the democratic process will become to that extent unrepresentative.

The need for action is serious and immediate. Consider, for example, the situation related to the biological hazards of radiation. It is now 6 months since the radiation committees of the National Academy of Sciences issued a report that called for a series of immediate actions including, among others: (i) the institution of a national system of radiation exposure record-keeping of all individuals; (ii) vigorous action to reduce medical exposure to x-rays; (iii) establishment of a national agency to regulate disposal of radioactive wastes; (iv) establishment of an international program of control and study of radioactive pollution of the oceans; (v) considerable relaxation of secrecy about dissemination of radioactivity. In addition, the committees pointed out that "The development of atomic energy is a matter for careful integrated planning. A large part of the material that is needed to make intelligent plans is not yet at hand. There is not much time left to acquire it."

There is no evidence that these urgent pleas for action have yet met with any significant response. Clearly, this is a matter that requires the persistent attention of all scientists. It exemplifies the pressing need that scientists concern themselves with social action. In this situation, the AAAS carries a special responsibility. As one of our past presidents, Warren Weaver, has said: "If the AAAS is to be a vigorous force for the betterment of science, it cannot continue in the face of crucial situations with closed eyes and a dumb mouth." This responsibility has already been recognized. What is needed now is a way to meet it.

Humble Oil Company Radiocarbon Dates I

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The radiocarbon ages given in Table 1 were determined by the geochemical research group of the Production Research Division, Humble Oil and Refining Company. The method used, which has been described in a previous publication (*1*), was proportional counting of carbon dioxide that had been prepared from the sample under assay. The counter was filled to an absolute pressure of 5 atmospheres of carbon dioxide in all cases.

The ages are based on a half-life of radiocarbon of 5568 ± 30 years (*2*) and on an assay of contemporary carbon, whether in the form of organic carbon or of calcium carbonate, of 20.27 ± 0.15 count per minute for the particular counter used. This value was obtained by the extrapolation to zero age of assays of tree rings greater than 50 years in age. Background counting rates were in the neighborhood of 5 counts per minute, with a statistical uncertainty of ± 0.07 count per minute.

The samples described in the table were obtained from sites that have been studied primarily for obtaining archeological information. However, since the stratigraphic relationships of a number of the sites in the lower Mississippi Valley have been developed, the radiocarbon ages of the archeological samples contribute not only to the archeological history, but also to the development of an absolute chronology of sedimentary events in the region.

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References

1. H. R. Brannon, M. S. Taggert, Jr., M. Williams, *Rev. Sci. Instr.* 26, 269 (1955).
2. W. F. Libby, *Radiocarbon Dating* (Univ. of Chicago Press, Chicago, Ill., ed. 2, 1955).

Table 1. Radiocarbon dates obtained on archeological samples. All ages are given in radiocarbon years before the present.

Description	Sample No.	Age (yr)
Manny site, Issaquena County, Miss. Sample from a deposit that consisted largely of carbonized fragments of cane (*Arundinaria macrosperma,* identified by E. S. Barghoorn, curator of paleobotany, Harvard University). From cut C, − 23 to − 43 cm, uppermost stratum. Should date the Coles Creek phase. Collected 20 April 1954. Submitted by Phillip Phillips and Robert E. Greengo, Peabody Museum, Harvard University.	O-12 O-23 O-27	1130 ± 100 980 ± 100 1080 ± 100 Average 1050 ± 100
Thornton site, Issaquena County, Miss. Sample from a deposit of carbonized cane and wood about 22 cm in diameter. From cut C, − 140 to − 158 cm. Should date the Issaquena phase. This is a regional phase in the lower Yazoo Basin that probably falls within the Troyville period as defined by James A. Ford, American Museum of Natural History, and others. Collected 2 March 1954. Submitted by Phillip Phillips and Robert E. Greengo.	O-24	1410 ± 100
Thornton site, Issaquena County, Miss. Sample from a deposit of carbonized materials, about 22 cm in diameter, including a greater proportion of wood than that tabulated under sample O-24, but otherwise similar. From cut D, − 128 to − 141 cm. Physical stratification good. Should date the Issaquena phase. Collected 3 March 1954. Submitted by Phillip Phillips and Robert E. Greengo.	O-25	1420 ± 100