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THE CRISIS BETWEEN SCIENCE AND SOCIETY—A MODERN PARADOX[1]

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At the New York meeting of the American Association for the Advancement of Science, held last December, a report was given by the Committee on Social Aspects of Science (Pigman *et al.*, 1957). To the public at large this report was received as one of the most significant contributions of the convention. The public press gave it wide publicity; science writers commented in detail; a few publications reprinted the entire report of the committee. Much discussion and comment were stimulated throughout the country.

This report makes clear 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 precepts have become predominantly dependent on science, the discipline has failed to attain its appropriate place in the management of public affairs." The report also makes clear that " . . . there are indications that the public interest in science is not commensurate with the important role of science in society."

Since the Renaissance, and especially since the Industrial Revolution, there has been no force greater in the development of Western civilization than the development and application of modern science. We have gone progressively through the ages popularly called the Iron, Steel, Machine, Air, Electronic, and finally the Atomic Age. Each has appeared following a shorter interval of time as science has advanced at a tremendous rate of acceleration. Almost every aspect of modern life depends upon scientific development—our communication, transportation, utilities, agriculture, manufacturing, medical treatment and health preservation, etc.—at every turn we are served by innumerable developments of science and technology. Yet, in spite of this dependency upon modern science, there is an ever widening gap between science and society. Scientists as a working group are becoming more and more isolated, and as scientific knowledge increases, the public has less and less understanding and appreciation of the works of science. It is indeed paradoxical that contemporary society neglects the very source of its modern development.

Attitudes of the general public towards scientists are alarming. While everyone enjoys the fruits of science, little does the average person realize the source of these advantages which modern science has bestowed upon him. Our youth look upon scientists as "eggheads," "long-hairs," and "squares." In a recent survey (Purdue Opinion Panel, 1956) it was reported that 25 percent of the college students interviewed think that scientists as a group are more than a little bit "odd," and 14 percent think there is something evil about scientists. As a social group they are rated comparatively low in prestige by the youth of our country. Even lower on the scale is the prestige of science teachers. It is becoming increasingly

[1]This paper was read as an Honors Day Address at Kent State University on May 29, 1957.

difficult to attract good students to a career in science education. In this case a comparatively low financial reward is coupled with the unappreciative attitude toward science in general.

This attitude is often imparted to youth by their teachers and other adults who carelessly create an unfavorable impression. People often do not realize the harm done by derogatory remarks, even when not made to be taken seriously, or when given out merely as incidental statements. These slighting remarks may become seeds which will later grow into antagonistic attitudes. Recently this problem has been summarized with a suggested solution by Michael (1957). Scientists should take the initiative in correcting this situation.

The public press and other media of mass communication exert a great influence in shaping public opinion. The A.A.A.S. report (1957) states that ". . . science receives an unduly small share of the budget of newspaper space or broadcasting time. The situation reflects a rather low level of interest in science on the part of the public." On the other hand a recent survey (Anon, 1956) has shown that newspaper articles on scientific subjects are consistently among the most interesting to newspaper readers. Possibly it is the erroneous belief of journalists that the public is not interested in matters of science which results in such poor coverage, thus creating a vicious cycle. Better press relations could do much to strengthen the ties between science and the public.

A recent example of damaging reporting appeared in a nationwide syndicated column (Fulton Lewis, 1957). It was entitled "Zany Projects" and was an attack upon the spending of tax money by the National Science Foundation for scientific projects which to the columnist appeared to be "zany." A number of selected titles were given to illustrate the argument. Undoubtedly to the uninitiated, the projects may seem of little value if not entirely worthless. Apparently the writer of the column was not familiar with the stand taken by Warren Weaver (Piel, 1955) who said, "The most imaginative and powerful movements in the history of science have arisen not from plans, not from compulsion, but from the spontaneous enthusiasm and curiosity of competent individuals who had the freedom to think about things they considered interesting." Before the days of penicillin a research project on bread mold would certainly appear to the writer of this newspaper column as a "zany project." In the mid-nineteenth century a financial grant would not likely have been given to Faraday or Clark-Maxwell for pioneer research on electricity, but our columnist would not likely hesitate to recommend a grant for the scientific study of the gas light, as Harrison Brown (1956) has so well pointed out in his article on "The Case for Pure Research." He then summarized with the statement, "Too few laymen recognize the extent to which the eventual practical applications of a scientific discovery are unpredictable." Warren Weaver (1955) puts the matter this way; "An important characteristic of science . . . is its incapacity to be impractical." A past president of The Ohio Academy of Science (Rea, 1926) earlier put forth this same idea with his statement, "Useful inventions are invariably developed from apparently useless knowledge." The public does not seem to realize that pure research leads to new knowledge which is the capital upon which applied science draws for development.

Scientists are partly to blame for the situation because they have too often remained aloof from the rest of society. Scientists often ignore social issues and are even notorious for their negligence in supporting their own cause. A recent study by the American Association for the Advancement of Science (A.A.A.S., 1955) points out how poorly the majority of American scientists support their own professional organizations. They are also guilty of being ignorant of what is going on in branches of science outside their own specialty as well as in public affairs. Quincy Howe (1956) has shown that the use of modern weapons is graually breaking down the barriers between scientists and the public, and he regards this as a significant move in the right direction.

One of the most important aspects of the crisis between science and society today is that of training teachers and educating the public-at-large in the field of science education. There has been a marked dwindling of enrollment in the science courses of our schools generally. Fewer college students are preparing for science teaching, and many who have recently entered the field are not well prepared. The National Science Foundation, the A.A.A.S., state academies of science, and other organizations are attempting to improve science teaching through summer institutes and fellowships for further training to raise the level of quality and to attract competent young students to this field. Today it is necessary to have active recruiting to entice young people to prepare for the teaching of science and mathematics. There is danger, however, that such programs may take on the attributes of high-pressure salesmanship. Youth should be motivated towards careers in science and science teaching for the professional satisfaction these careers can offer rather than fancied rewards which seldom are realized. Financial rewards cannot be offered to attract teachers, but strangely enough even the attractive salaries offered by technology and engineering have not resulted in bringing sufficient people into these fields to meet the ever-growing demand. J. W. Still (1956) recently stated in a communication to the editor of *Science*, "Young people are taking a dim view of both basic and applied sciences as a career." It was encouraging to read in a recent issue of our local paper, the *Record-Courier* (1957), that a report compiled by a committee of citizens on planning a new high school stated "The people expressed the view that there should be an increasingly strong program in the fields of science and mathematics—those surveyed (90%) believed that science and mathematics facilities of the new building should take precedence." It is encouraging to see a public group realize the importance of the teaching of science and mathematics to modern youth. Also, it is only fair to point out that while considerable emphasis has been given recently to the poor preparation of many science teachers and to the inadequate science program in many schools, it should not be forgotten that we do have many fine teachers of science who are doing admirable work in teaching science and in stimulating their students to pursue a career in science. There are many science teachers with advanced training who have resisted temptations to take more remunerative employment elsewhere because of their interest in high school youth and the satisfaction they derive from stimulating and encouraging young people in their classes and laboratories. Each year as I attend the district and state Science Day exhibitions, sponsored by The Ohio Academy of Science, I marvel at the creativeness and productivity of our better high school students. Many of the projects are of such quality they would do credit to far more advanced students. Indeed there is a good deal of fine science teaching accomplished today, and there are many promising students who are looking forward to a career in science or science teaching; but unfortunately, the number is not great enough to meet the increasing demands for research workers, technologists, engineers, and science teachers. It is the duty of society to provide our gifted young people with suitable training and adequate facilities to develop their natural abilities and head them toward a satisfying career in science and science education. It is obvious that without meeting the demands for qualified science teachers, the production of scientists will dry up at the source.

In contrast to the situation in the United States, we receive reports that the Russians are making tremendous strides in the training of scientists, technologists, and engineers. Indications are that the rate of increase of these specialists in Russia will continue to be greater than ours (Dargush, 1957). Also, London (1957) has warned us not to regard Soviet science in the light of the unsavory situation created by the farce of Soviet genetics. In other disciplines the Russian scientists have been able to advance one way or another without being hindred by political doctrine. Merle Fainsod (1957) wrote a few months ago of "The technical dynamism running through Soviet society." He noted, "The important people were engineers and scientists. . . . The university is an interesting mirror of the values of Soviet life, with science and technology very much in the forefront." In European countries, in general, scientists are very highly respected; in many cases they rate higher in the social scale than the physicians and surgeons. It has recently been called to our attention by John Lear (1956) that "Soviet Russia is assigning scientific attaches to its embassies for the first time in its history—the United States has no scientific attache anywhere." It is unfortunate that our top officials concerned with problems of a scientific age are rarely trained in a scientific tradition. Several years ago the Executive Committee of the A.A.A.S. made clear that "In our modern society it is absolutely essential that science—the results of science, the nature and importance of basic research, the methods of science, the spirit of science—be understood by government officials, by business men, and indeed by all the people." Science needs better representation in our government at the higher levels.

While comparisons are interesting, we must not draw the conclusion that Russian scientists play the important role in society which the above statements would seem to indicate. A news item recently published in *Science* (Anon, 1957) informs us that "A majority of the Soviet Union's most eminent mathematicians and physicists have challenged the present political control of Soviet science. They appear to have made progress in their demand that leading Soviet scientists be allowed democratic control over the development of Soviet science." While we can not boast of the tremendous increase in the training of technicians currently being attained in Russia, our scientists do not come under such political control, the ends of which might be questioned by democratic people.

While modern science on one hand has improved health, longevity, comfort, wealth, and security, it has on the other hand raised a serious threat to all of these. With industrial development there have long been problems of air and water pollution. Now a new source of environmental contamination has been created. Radioactive fallout from atomic and hydrogen bomb testing poses a serious problem. We are assured by some authorities that the level of fallout at the present time is far below the toleration level. Just last week a front page story in the *Cleveland Plain Dealer* (Robertson, 1957) carried the claim of a radiologist that radioactive fallout in the atmosphere is no more serious than the luminous dial of one's wristwatch. However, Albert Schweitzer (1957), who has joined the leadership for abandoning hydrogen bomb explosions, calls our attention to the possible consequences of even low level contamination. In his report the following case was cited. When the radioactivity contamination of the Columbia River was analyzed, it was found to be at a very low level. However, the radioactivity of the microscopic plants and animals living in the river was 2000 times higher, that of the fish feeding on these organisms was 15,000 times higher, and that of ducks eating the aquatic life was 40,000 times higher. Nestling swallows, fed on the insects coming from this river, had a radioactivity level 500,000 times greater, and in the egg yolks of water birds feeding in this area the radioactivity level was 1,000,000 times greater than in the water itself. Apparently in this case the plants and animals living in a medium of relatively low contamination concentrated the radioactive materials in their bodies. Should man enter this food chain by eating the fish and game which have acquired a high level of radioactivity, man would become endangered even though the atmosphere and the waters about him may show a low level of contamination. The study of Henderson, Robeck, and Palange (1956) on the Columbia River showed that "The river organisms concentrate radioactive materials to a considerable degree, up to nearly 10,000 times the total beta activity in the river water." They concluded, "Because fish and other aquatic organisms concentrate radioactive materials many times above the levels found in water, the use of these organisms for human or animal consumption presents a potential public health problem." It was calculated, however, that as of that time the levels of radioactivity in the flesh of the fish studied were not dangerously high.

Strontium 90, which makes up the bulk of radioactive fallout, behaves chemically much like calcium, and hence this radioactive strontium accumulates and becomes concentrated in the bone tissues. Here it is close to the blood forming tissues in the bone marrow and is capable of producing fatal blood diseases. Last week a very important article by E. B. Lewis (1957) concluded after a very searching study, "It is estimated that a five to ten percent increase in the current spontaneous incidence of leukemia would occur if the population were to reach and maintain a body level of strontium 90 amounting to 1/10th of the 'maximum permissible concentration.'" An editorial comment on this article (DuShane, 1957) concluded, "It is apparent that the atomic dice are loaded. The percentages are against us and we ought not play unless we must to assure other victories."

To date, many scientists are at sharp disagreement as to the actual and potential hazards of radioactive fallout as illustrated in some of the recent literature (Libby 1956a, 1956b; Libby, Brown, and Lear, 1957). Two trends are not without significance. The level of maximum permissible concentration has consistently been lowered, and even the strongest arguments given against fear of fallout dangers have recently been tempered with the admission that potential danger does exist whether or not damage is present now from past explosions. Lapp (1957) has pointed out, "Values for MPC have been revised downward steadily during the past two decades as more knowledge of the ultimate biological effect of skeletally retained radioelement has accumulated." Libby (1956a) is confident that up to the present time the amount of fallout has not reached a dangerous level. He wrote, "It is possible to say unequivocally that nuclear weapons tests as carried out at the present time do not constitute a health hazard to the human population insofar as radiostrontium is concerned." However, it is well to keep in mind the statement by Snyder (1957) that "The able and authoritative summary reports on the biological effects of atomic radiation by the committees of the National Academy of Science which studied this question expose our serious deficiency of many fundamental data. This deficiency is perhaps nowhere so conspicuous as in the area of genetics, and particularly the genetics of the human species." It is clear that atomic energy is not an unmixed blessing. Much is promised to man with the development of atomic energy, but it is not without its own inherent dangers. It can raise the standard of living, improve health, fight disease, furnish unprecedented energy, revolutionize industry, or it could lead to the ultimate annihilation of man, either directly by devastating war or the contamination of natural resources and internal degeneration of man through disease. Snyder (1957) sums up the situation this way, "It would be indeed tragically ironic if the same thermonuclear reactions that, by taking place in the sun, make possible our very existence on this earth, should, through our own social bungling, lead to our destruction."

It is very clear how modern science affects society. However, it is neither obvious nor commonly realized that the reciprocal relationship is also true. Society bears great influence on the development of science, particularly of the applied sciences. Hafstead (1957) recently stated the matter succinctly: "It is society itself, and particularly the nontechnical part of society, which creates the demands which are the motive force behind our technology." Albert Schweitzer (1957) emphatically states, "Public opinion of this kind—works through just being there." In the final analysis it is society itself which dictates the course of applied science and technology.

The periodic proposals of a moratorium on scientific advancement are certainly not a solution to the crisis between science and society. Considering the benefits derived from the past accomplishments of science and technology, it is somewhat surprising and paradoxical that a crisis should exist at all. We are in the midst of a scientific revolution. It may lead to a better world; it could lead to pandemonium. Society is becoming more and more dependent upon science, but society in the end will tip the scales in the direction toward which science shall proceed. Increased knowledge leads to increased control of the environment and the harnessing of the forces of nature for the benefit of man. Learning to adjust to a new technology rather than stopping the program for society to catch up, seems to me to be the only rational solution. And hand in hand with working toward harmony between science and society, is an undercurrent of moral issues involved in striving for a better and fuller life. Solutions to these problems will not be easy. Time has permitted only a brief mention of but a few of the many problems facing modern man and his relations to science. Will the crisis lead to cooperation or to chaos, a better life or annihilation? The responsibility rests equally upon science and society.

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