Science: Boon or Bane?

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As I contemplate the space ship that we call earth, and what is taking place on it, I am reminded of a hot and breathless day many years ago. From our house perched on a hilltop we could see 30 to 40 miles in all directions. Early in the morning local thunderstorms began to build up in a half dozen localities around the horizon. As the day wore on, they slowly grew in size without seeming to move much from their centers of origin and finally began to run together. By noon we were ringed by ominous storms which crept inward from all sides. When they got near enough for the thunder to become apparent, the sound was stifled, as though it had been covered with a blanket—such was the effect of the solid ring of storm clouds. Finally about 3 p.m. the storm closed in and for three solid hours it rained as I had never seen it rain before. When the storm finally played out at 6 in the evening, we found that 5 trees had been struck by lightning within 200 feet of our house.

I sometimes think that we are in a comparable situation in the world in which we reside. All around us, there is the rumbling of storms. Some are growing in size and intensity. Some are much too close for comfort. One wonders whether they may not soon merge into one cataclysmic world conflict that will leave civilization devastated and all but destroyed.

My thesis today is that science and science-based technology are to a large extent responsible for the magnitude and intensity of the storms brewing all about us and that it is therefore a major responsibility of scientists and engineers to work toward their dissipation before they overwhelm us. Science has been an incredible boon to mankind in alleviating suffering and disease and in developing convenience and comfort, but it has also had a baneful effect which it is our responsibility as scientists to counteract.

In saying that science and technology are largely responsible for the magnitude of the world's problems today I do not believe that I am exaggerating. The world has always had its problems and its conflicts, but in the prescientific age these were usually local in extent, never world-wide. But with the shrinking of the globe and the expanding of the human population, both of them resulting from the activity of scientists, it becomes constantly more difficult to contain foci of trouble. Conflicts beginning in one region have a way of spreading into other areas and involving peoples in all sectors—as witness our involvement in Vietnam.

The world we live in is a completely different world from the one our founding fathers knew. Thomas Jefferson and Benjamin Franklin would have recognized themselves as being in the same world if they had been transported back a thousand years. The world of 800 AD and 1800 AD differed only in relatively minor details. But if these

two gentlemen could have been transported ahead—not 1000 but a mere 170 years or so, they would have thought themselves on a different planet. Scarcely an activity, even the most trivial, would be performed in the same way and with the same equipment that they were used to. Scarcely an aspect of civilization would be recognizable—communication, transportation, housing, manufacture—all would be utterly new and miraculous—and all of it due to science and science-based technology.

But it is not just the world of gadgets that has been transformed by science. Science has also had a profound effect on the minds and aspirations of man. In pre-scientific days, the undeveloped parts of the world were largely isolated, knowing little about other areas than their own. The life people led they took more or less for granted—its hardships and privations were accepted without serious question. The masses were even reconciled to the presence in their midst of great wealth in the hands of the few who owned all the land and who determined the lot of the many. These days are gone. Science has opened up the world to everyone. Through radio, television and other forms of mass communication there is scarcely a part of the world where the inhabitants have not learned how the rest of the world lives, of its comforts, its freedoms, its widespread distribution of the ownership of land, its literacy. People everywhere now have an image of the affluent society, and for the first time an overwhelming tide of discontent is sweeping across the world, stimulated and encouraged, of course, by sinister political groups who hope to exploit the miseries of the world for their own benefit. People everywhere are demanding land of their own, freedom to live their own lives, education to open doors of opportunity, the conveniences and even the luxuries of civilized life. Science and the technological fruits of science have opened up the world, have brought all areas into close contact and made us all close neighbors.

At the same time, through its other activities, science has created other problems that are almost overwhelming in their extent. One of these has come about through the development of weapons that have enormously increased the ability of already powerful nations to dominate and destroy, and are making hitherto powerless nations a threat to world peace. The increase in population which far exceeds the increase in food supply produces all the tensions that normally lead to war, and at the same time the potential destructiveness of modern warfare has increased at an exponential rate. The extent to which the fruits of science are being used for destructive purposes staggers the imagination. Take the matter of the arms race as an example. The military budgets of the world at present total over 180 billion dollars a year. If a man had begun to count at the rate of one a second in the year 4000 B.C., more than 2000 years before Abraham, and could still be counting, he would just be reaching 180 billion at the present day. And this is the military cost to the world for only a single year. Of this sum, 85% is incurred by 7 nations. This means a crippling loss to the economies of the vast majority of the nations of the world. It represents 8 to 9% of all the world's production of goods and

services (1). The effect is bad enough in the countries responsible for most of this expenditure; it is utterly disastrous to the underdeveloped countries which are trying to catch up with the rest of the world but are falling constantly behind because they think that they have to build up their military strength. As a result, the gap between the developed and the developing countries is constantly widening. In the developed countries the annual income increased during the years 1960-62 about $100 per capita, whereas in the developing countries it rose only about $5 (8).

In addition to the effect on the economy of nations, the military build up has had other serious side effects, such as the rise of suspicion, fear, and hatred among the nations and a consequent heightening of tensions. Another side effect has been the pollution of the atmosphere and the soil by radioactive wastes. During the years leading up to the recent test ban treaty, there was a noticeable increase in the amount of radioactive contamination in the atmosphere. The 1961-2 atomic explosions caused the level of strontium-90 and caesium-137 to more than double. The carbon-14 level in 1964 was 85% over the natural level (5). As long as the test ban treaty continues to be observed there is hope for a gradual reduction in their level. The chief danger at present lies in the fact that neither France nor China has been willing to adhere to the treaty.

But it is not merely the misuse of the results of scientific research that has led to the major problems facing the world today, the legitimate and proper use of scientific discoveries has also posed severe and all-but-insoluble problems. This is true, for example, of those sciences that are basic to our communication and transportation systems, for these are the sciences ultimately responsible for shrinking the world down to the point where we all know what the other parts of the world are doing, resulting in the rising tide of expectation on the part of the masses. Nothing happens these days without having widespread and often world-wide repercussions. The prejudices of an Asian potentate, the mad antagonisms of a Caribbean dictator, the dreams of grandeur of a mid-eastern tyrant obsessed by hatred, all have global importance. This was only made possible because of our modern ability to communicate instantly and to travel swiftly around the space-ship called earth.

All of this has come about, not by the misuse of the products of science but as a result of the proper and altogether desirable utilization of scientific information. If all human beings were men of good will, these results would be wholly beneficial, adding enormously to the pleasure, the comfort and the interest of life on our planet. Unfortunately, however, man is still the most savage of all animals. In a world dominated by such a species the glorious feats of the sciences basic to the arts of communication and transportation are bound to have some unfortunate consequences and to be partially responsible for many of humanity's problems.

But perhaps the sciences that have contributed as much as any to the creation of man's problems are those that are most devoted to the alleviation of man's ills—the health and sanitation sciences—

the most humanitarian of all in their ideals and aims. I would like to dwell for a moment on the situation which they have brought about, as an example par excellence of how science, that has been a great boon to man, has also had a most baneful effect.

It can be argued with justification that the number one problem facing the human race today is that of population. Perhaps this is an even more serious problem than the threat of nuclear war, since there is a real likelihood that the latter will never eventuate, but there is no way whatever of avoiding the population problem. Even if we take all possible steps to curtail birth rates, the human population on an already overcrowded planet will still continue to grow.

The main reason for this sudden population explosion is not primarily an increase in birth rates but rather a dramatic decrease in death rates. Birth rates have continued at a more or less uniform level in recent years, while death rates have decreased in all parts of the world. Even in India, with its famine and overcrowding, the death rates fell by 30% in the period 1946-1960. This is the smallest decrease of any country of the world. In many countries the death rate decreased 50% or more in this short period of 15 years, and in a few countries it decreased by over 60% (4). This is the result largely of the introduction of public health measures. To some extent the decline is also a result of improved food production, but in comparison with the effect of public health measures this is of minor significance.

Nor have public health services reached the level of diminishing returns. Most of the decreased death rate is the result of reduced infant and child mortality, but we have a long way to go before the less developed areas of the world begin to approach the mortality figures of the most advanced nations. For example, infant mortality (i.e., deaths during the first year per 1000 live births) is less than 16 in the Scandinavian countries; in the U.K. the figure is 20 and in the USA 23.4: but in Burma and Laos it is 221, in Cambodia and Thailand 179, in Mexico 125, in central Africa 230, in British Borneo 253 and so on (2, 3). A quarter of all the babies born in North Borneo die in their first year. In South Africa, infant mortality among the Bantus approaches 400 (i.e., 40%) as contrasted with 27 (2.7%) for the white population (7). As medical and public health services improve in these regions, and who is there who would not encourage such improvement, the population is bound to increase at an even more phenomenal rate than is now the case, and these are the countries that oftentimes already have the highest birth rates and the highest annual rate of population increase. At present rates of increase, the population of Cambodia and India will double in about 30 years, of Mexico in 22 years, of North Borneo in 19 years. Contrast this with the United States and the USSR where doubling will occur in about 50 years at current rates, or most of the Scandinavian countries where it will take about 100 years for the population to double (10).

The population problem is a relatively new one and one that is a direct result of scientific activity of the most laudable type. A solution must be found if the world is not to sink into utter chaos and this solution must involve the scientist as well the social scientist.

Some alleviation can be achieved by increased agricultural productivity, and every possible emphasis should be placed on endeavors to bring under cultivation every bit of useable land, to develop improved strains of crop plants and farm animals, to train natives in modern methods of agriculture, and to develop new and palatable protein-rich foods from sources not now considered to be edible. But when all has been done along this line that can be done, the results are not likely to be sufficient to compensate for the growth of human population if present rates are permitted to continue. It is perfectly clear that the only solution to the problem of over population is limitation of birth rates. If birth rate levels could be brought in line with decreasing death rate levels, we might approach a stable situation, in which conditions would be no worse than they are at present.

It is sometimes argued that increased industrialization in underdeveloped areas of the world will make possible increased levels of population and that industrialization is therefore one solution to the problem of over-population. But there is one element in the situation that is forgotten by those who argue thus, namely, that all these people must be fed and clothed. It is true that industrial societies are able to support denser populations than primarily agrarian societies, but these have to be backed up by an agrarian segment of the population somewhere. The real bottleneck in most of the world is agricultural production. There is not enough food being produced now to nourish the world population properly.

In order to tackle the population program with some measure of success, a systems approach is essential. Many things are needed and they are all needed at once if results are to be achieved. On the agricultural front, better seed alone will not solve the problem if the soil is deficient or if plant diseases are not controlled. Superior strains of farm animals will thrive only if they are provided with an environment where they will develop and reproduce satisfactorily. And nothing that is done to improve agricultural plants and animals will be of any use until native farmers are taught, and accept, improved methods of agriculture, and native populations learn to accept new and more nutritious food products. Increase in agricultural productivity calls for a massive and simultaneous attack on all fronts and results are bound to come slowly. Even at best, however, there is no possibility that improvements in this direction will keep pace with growing populations. Even if food production can be made to keep pace with the growth of population, the absolute number of hungry will increase, even though the proportion of hungry remains constant. But agricultural production is not keeping pace with the growth of population. It has been estimated by the head of FAO (Dr. Sen) that an annual increase of 4% in agricultural production will be necessary to maintain the present balance between food and people, assuming a continuance of the present annual increase in population. At present, however, the annual increase in agricultural production, instead of being 4%, is less than 2.5% (6). (A recent article in the N. Y. Times quotes the same source as stating that agricultural production must now increase

by 7% instead of 4%, in order to maintain the present balance between food and people.)

One is forced to the conclusion, therefore, that increase in food production is not going to be enough, that reduction in the birth rate is the only practical means of stemming the tide of burgeoning populations. The systems approach to the population problem must include not only a simultaneous approach to all aspects of the agricultural problem—it must also include a monumental attack on the problem if high birth rates. Scientists must approach the problem from both sides simultaneously—slowing down the rate of population increase and speeding up of the rate of production of food.

Before leaving this example of a problem caused by scientific activity, I should emphasize that what I have been talking about is how to make possible a balance between food and people sufficient to enable all men everywhere to keep soul and body together. But of course this is not going to satisfy the peoples of the underdeveloped countries. They want something more than mere existence—they want some of the luxuries that they see in American movies and on TV shows, and hear about on the radio. To give them what they really want is unfortunately utterly impossible, even with the population level as it is, to say nothing of increasing levels. To quote Prof. Philip M. Houser of the University of Chicago: "If you assume that all of the world's resources, present total product, all goods and services produced, were available, and then ask how many people could the world support at the European level of living, the answer is: about 1,500 million and we already have a population of 3,200 million." He then asks how many people the world could support "at the North American level of living; the answer is: only 500 million, and we have 3,200 million." (9). It is a sobering thought that the human population is already too large for everyone in the world to be able to live at the European or American level of affluence or anywhere near it. The earth cannot produce enough food and other necessary commodities, no matter what we do, to permit over 3 billion people to live as we in the United States live. The best that can be hoped for is to eliminate starvation and malnutrition from the more than half of the world's population that now suffers from these misfortunes, and the situation will certainly become worse before we can achieve even this limited goal.

I have chosen increasing population as one example of the type of problem that has come into being as a result of scientific discovery and activity. It is only one, though the most important one, of the many problems that face civilization today as the result of scientific activity. I could dwell on other problems such as the side effects of increased industrialization with its attendant increase in the production of wastes, resulting in air and stream pollution, with its accelerated demand upon natural resources, threatening the future of our forests, our lake and ocean fronts and the destruction of areas of natural beauty. Or I could discuss automation which has helped accentuate many of our problems. Negroes, for example, forced off the farms in the south by the development of automation, have migrated in increasing numbers to the cities of the north, only to find that the only jobs which

they are capable of holding are disappearing, again because of automation. These are social and economic problems, but they have developed largely because of science and science-based technology, and they are not going to be solved without the assistance of the scientist and the technician.

When one considers the role that science has played in creating these global problems, and the fact that they cannot be solved without the aid of science does it not seem that we scientists, individually and collectively, have a responsibility to do everything we can to assist in preventing the holocaust that will engulf mankind without their assistance? What then should we be doing?

At the very lowest level, we should be more seriously and actively concerned about these problems and should as individuals seize every opportunity that comes our way to make our contribution. This means that we should emphasize wherever possible in our teaching the nature and magnitude of the problems facing the world and the role that science must play in meeting these problems. It means that we should seriously consider the matter of relevancy in our research. Basic research is essential, and one cannot always see just how one's findings will benefit mankind, but even the basic scientist can often choose problems that give promise of adding to our store of useful knowledge. Too often, scientists tend to retreat into their ivory towers, and ask for only two things—financial support and freedom from disturbance. In view of the increasing severity of the difficulties that beset mankind, it is quite certain that relevancy is going to play a much larger role in the future as a criterion upon which support will be granted individual scientists. More and more, scientists should be studying the world's major problems, and attempting to relate their research, whether basic or applied, to the solution of these problems.

The individual scientist, in addition, should be willing to devote a portion of his time to the initiation of, and participation in, programs designed to attack specific social problems. Many scientists gladly do this now. For example, the National Academy of Sciences—National Research Council, which carries on its work almost exclusively through unpaid committees, is currently using the talents of over 5,000 different scientists. Many more are serving as panelists and advisors to the various government agencies and private foundations. Much of this activity is for the benefit of science itself, but to a large extent it also involves the application of scientific knowledge and competence to problems related to the public welfare. These are important forms of service and everyone who is asked to participate in such activities should respond with enthusiasm to the extent that his regular duties permit.

It is also important that we do all we can to inform the general public about the nature of science and the activities of scientists. There is a vast realm of ignorance even in our relatively enlightened populace, who tend to think of scientists as miracle workers and who evaluate science only in terms of dollars and cents. We occasionally encounter newspaper men and congressmen who do not understand what science is all about, and poke fun at research programs that they do not understand. We even see an occasional public official who cannot understand

why a state university should engage in research, not realizing that it is scientific research that has transformed the world of Franklin and Jefferson, and it is research that will discover the principles and develop the mechanisms by which the ills of society will be cured in the future if cures are to be found. There is much that individual scientists can do to make the general public more aware of the serious problems that face humanity, as well as inform them about science, its aims and ideals, its objectives, its methods and limitations, what it contributes to Society, and the fact that the most esoteric research often leads to the most epoch-making advances. Scientists should be ready and willing to respond when called upon as speakers or in other ways by civic groups and organizations of all kinds.

But although as individuals can contribute greatly to the education of our citizenry and the solution of Society's ills, it is through organizations that most of the solutions of the world's problems will continue to be made. As members of such organizations, or when called upon by them, individuals can make their most important contributions. And many of these organizations are greatly in need of the services of competent scientists. For a good many years I was a member of the Unesco Committee of the National Research Council and for six years served on the board of the International Union of Biological Sciences. On many occasions we attempted to find American scientists who would be willing to devote a portion of their time, or in some cases to take leaves of absence for a year to two, to carry out projects of an international character. It was much easier to find European or Asian scientists than Americans for these assignments.

But coming back from the global to the local scene, it may not be inappropriate to ask what the role of the Indiana Academy of Science should be in assisting the citizens of this state with their problems and in informing them about science and scientific progress. For many years the Academy has carried on an active program involving the holding of semiannual meetings and these have been of great value in knitting the scientists of the State into a cohesive body and in stimulating their research interests. The Academy has published the findings of its members and it has supported to a limited degree their investigations. These activities have been primarily for the benefit of the scientists themselves. In addition, however, the Academy has carried on a very active and valuable program on behalf of the youth of the State, through the Junior Academy and through its support of science fairs. But what has the Academy done on behalf of the adult laity of the State? In common with many other State academies, it must be confessed that it has done very little to inform the general public about what is going on in the realm of science, and it has taken little part in assisting the State or its citizens in the solutions of problems that require scientific competence and judgment. Perhaps the time has come for the Academy seriously to consider this matter.

Why should a State Academy not bear the same relation to the State government that the National Academy of Sciences does to the Federal Government? The National Academy is a private organization but with a congressional charter, and an obligation to advise and assist

the Federal Government in matters involving science. It responds to requests from Congress or the Executive Branch, and is also at liberty to offer suggestions and advice on its own initiative. More and more the bills before Congress and the decisions that must be made by the President and his Cabinet involve science. It is rare to find a major piece of legislation that does not require expert scientific advice and opinion. So complex has become the involvement of the Federal Government in science that the President's Office has now established the President's Science Advisory Committee (PSAC) with its associated Office of Science and Technology and the Federal Council on Science and Technology; and most of the major government agencies, even including the State Department, have scientific offices or divisions, often of huge proportion. Congress itself has created its Science Policy Research Division in the Library of Congress. Thus, it is realized in Washington that science is involved in a major way in most governmental decisions and determined efforts are being made to secure the necessary scientific advice, in part from governmental sources, but on matters of major importance, also from the non-governmental National Academy.

The same situation undoubtedly applies at the State level. Both in the legislative and executive branches of the State government decisions must often be made that involve matters of a scientific nature. The Constitution of the Academy states that "Inasmuch as the State makes an annual appropriation to assist in publication, the Academy shall, upon request of appropriate officials, act through its Executive Committee as an advisory body in the direction and execution of any investigation within its province—." Perhaps the time has come for the Academy to take this responsibility more seriously, to study this matter and develop recommendations regarding the best way for the State Government to capitalize on the scientific competence that exists in such abundance in the State, and that is so little utilized at present.

It is fortunate, therefore, that President Lindsey of the Academy has seen fit to set up a committee under the Chairmanship of Prof. Willis Johnson of Wabash College whose function it will be to study in depth the whole problem of the Academy's responsibility to the citizens and government of the State and to recommend steps that might be taken by the Academy to make it of increasing usefulness to the people of our community. This is a step that requires the wholehearted support and cooperation of the membership of the Academy. I hope that all of us will assist the committee by submitting ideas and proposals for programs, and by agreeing to serve in the development of such programs when called upon to do so. It is quite possible that stepped-up activity on the part of the Academy in this direction may contribute greatly to the strengthening of the economy of the State.

In conclusion, let me add that, in discussing current problems that have resulted from scientific activity, and which it is a responsibility of scientists to help solve, I have chosen to emphasize one or two that are of direct concern to mankind as a whole. There is a whole category of problems in addition, however, that have to do with the relation of science to society, and to government, about which I will

not have time to speak. How should science be supported? To what extent should tax money be used for research? Should the government support basic as well as applied research? Who should decide the areas that should be supported? Can the government support research without interfering with the freedom of the investigator? To what extent should geography enter into the question as to how to distribute support? How can the research and teaching functions in our colleges and universities be coordinated? These are but samples of the many problems that face government, educators and the public in general with regard to science—and their relation to it. As the Indiana Academy of Science considers its future role in the State, it will no doubt be concerned with these problems, as well as with the larger ones I have discussed, and can no doubt make a major contribution toward their solution also, especially as they relate to the State of Indiana.

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