Our Responsibilities As Scientists

By J. RUD NIELSEN

You have listened all day to papers in which experts have reported the results of their painstaking researches. I shall not give you another learned talk. Instead, I shall speak on a subject in which I have no special competence but which concerns all of us equally in these days of danger and fear. I shall try to discuss with you some of our responsibilities as scientists, or rather as citizens with scientific training. Since my main purpose is to urge you to think about these matters and not to prove any particular propositions, I shall speak with less caution than if I were presenting a technical paper.

After the Renaissance, the Reformation, and the voyages of discovery had broadened and liberated the minds of men, science emerged in the seventeenth century as an important factor in our civilization. In the next two centuries Newton's mechanics and later the theory of evolution exerted profound influence upon Western thought. The revolutionary developments of twentieth century physics, the theory of relativity, and the quantum theory, are now making their impact.

Science played only a minor role in the invention of the steam engine and in initiating the Industrial Revolution. However, during the last hundred years its applications to medicine and technology have become ever more numerous and fruitful. Life expectancy has increased, productivity has risen so as to make possible a widespread economy of plenty, and new means of transportation and communication have made the world smaller and have made its peoples more dependent on each other. In turn, the growth of science has been greatly aided by the prosperity resulting from the practical applications of scientific discoveries. The progress of science has also been facilitated by the rise of democratic practices and ideals, in particular by the gradual increase in intellectual freedom. However, while the benefits of science have been very great and promise to be vastly greater in the future, it is undoubtedly true that our most difficult problems today have either been brought about or been aggravated by scientific advances.

These problems are of three kinds. First, there are the internal cultural conflicts resulting from rapidly changing patterns of living and from the constant necessity of discarding old ideas and developing new concepts. Like most transition periods, ours is a time of uncertainty and confusion. Secondly, there is the all-important problem of preventing war. Because of epoch-making advances in applied nuclear physics, and the development of guided missiles and other weapons of destruction, it is hardly an exaggeration to say that success in solving this problem spells the difference between survival and suicide for the human race. Thirdly, there is the immense problem of creating a basis for lasting peace by developing the world's resources so as to satisfy the needs of a population that is at present increasing faster than the food supply. Of course, these three groups of problems are not independent, and the East-West conflict that dominates international relations today, and even domestic politics, is part and parcel of each of them.

Now, in this world of endless opportunities and great dangers brought about by science, what are our responsibilities as scientists and citizens? Well, there is at least one thing for which we are not responsible; namely, for the laws of nature being what they are. It is also clear that a worker in pure or basic science cannot be held responsible for the specific consequences of his discoveries; for these can never be foreseen when a discovery is made. With workers in applied science the matter is different. Their work is directed toward definite ends, for which they certainly should be responsible. However, their responsibility is limited by the fact that they usually have little or no control over the uses to which their gadgets or processes are put. Thus, the scientists who developed radio and television can hardly be held accountable for the truth of the information broadcast or for the artistic quality of the TV programs. Nevertheless, in a general way every scientist should feel responsible for the consequences of his work and his science. As Einstein once said: "Concern for man himself and his fate must always form the chief interest of all technical endeavors. Never forget this in the midst of your diagrams and equations."

It is clearly our duty to be as good scientists as our abilities and opportunities permit. That means, first of all, that we should cultivate those attitudes that are essential for scientific work: intellectual integrity, respect for facts, tolerance, courage, and humility. We should be prepared to defend science and should exert every effort to bring about such conditions that science can flourish. When necessary, we should muster the courage to fight for intellectual freedom and for the freest possible flow of scientific information. In doing so, we should make clear to our fellow-citizens that we claim these freedoms not in our own interest but because they are essential for the progress of science.

In the early days, scientists were allowed to investigate largely because no one paid attention to them. As Spinoza once said, "Had mathematics, in the eyes of men, the same kind of interest as politics, perhaps mankind would never have known what truth is." This situation has changed. We are now very much in the public eye, and intellectual freedom has been curbed behind the Iron Curtain and elsewhere, and it is being threatened even in our own country by groups dominated by fear and ignorance. We owe our freedom largely to the courage of religious and political dissenters. However, we must now assume a greater share of the responsibility for upholding freedom of thought and inquiry.

Outside the laboratories one of our chief responsibilities is to help spread information about the results of science and to impart some understanding of scientific method to our fellow citizens who have had no scientific training. The popularization of science is a difficult job, and not many of us are good at it. However, it is a collective duty that we must take seriously. We should endeavor not only to give information but also to promote those attitudes that are bound up with science. With tact and understanding, we should combat prejudice, intolerance, and all forms of absolutism.

I believe we can contribute to the solution of some of the present conflicts, and to the emergence of a more integrated culture, by passing on to others some of the lessons we have learned from modern science. One of the difficulties troubling this generation is the continual necessity of renouncing old ideas and developing new concepts to cope with new facts; and this is a mental process in which scientists have unique experience.

Thus, the study of atomic and molecular phenomena has forced physicists to abandon many of their most fundamental concepts and think in a radically new way characterized by Bohr's principle of complementarity. According to this principle, atomic phenomena can be completely described only with the use of different sets

of concepts, which are contradictory or mutually exclusive when applied with too great precision. Thus, to account for the behavior of electrons both the concept of particle and the concept of wave are needed, but they must be used with just enough latitude or fuzziness to avoid contradiction. A causal space-time description, as hoped for in nineteenth century physics, is not possible, and the old claims for objectivity have been revised.

Bohr has applied his concept of complementarity to a number of general problems outside the realm of physics, such as the problem of free will *vs.* determinism and the question of whether or not biological phenomena can be described in terms of physical science alone. He has not resolved these dilemmas but he has mitigated them by placing them in a new epistemological setting.

Now, if the simple phenomena of physics require diverse viewpoints, that must be even more true for the complex issues about which conflicts rage at present, and this is something we should make clear whenever possible. We should encourage the adoption of a "both-and" attitude in place of the "either-or" supposition of most public discussions. Thus, in the controversy over collectivism *vs.* individualism we should make clear that both are equally indispensable. Civilization, perhaps even life, could not exist without a considerable measure of collectivism. On the other hand, many human activities, including scientific work, require a large amount of individual initiative. It is usually futile to argue about which of two such extremes is the lesser evil. It is profitable only to search for the proper balance. The Greeks recognized this more clearly than we do today; and we in this country could learn something about balance and harmony from the small nations of Northern Europe.

In public discussions much confusion and misunderstanding arise because speakers fail to make their different viewpoints clear. As scientists we have a special responsibility to make clear the position from which we speak. Moreover, we should always adopt points of view as general as possible, so that we may have the largest possible ground in common with those with whom we discuss. Special tenets of professional, partisan, or sectarian nature should always be left out of public discussion. A fundamentalist and an atheist can have a profitable discussion about theology only if both, for the purpose of the discussion, adopt an agnostic point of view and use the word "god" to designate a prevalent and important human concept.

In discussions with non-scientists we should always be patient and friendly. We should keep in mind that many of their problems are directly or indirectly caused by science. If they have had to give up old ideas, of if cherished beliefs have lost their old meanings to them, we should be ready to help them find new ideas or new meanings. It is often claimed that science is concerned only with facts and has no regard for values. There is some truth in this. However, for psychology and sociology values are facts; and it is wrong to assume that science has nothing to offer as a basis for ethics. Indeed, the very integrity that forbids the scientist to let feelings or human value judgments color facts is an ethical quality, as are many of the other principles or attitudes that are prerequisites for, or by-products of, scientific work. In some scientists, at least, they may well be said to constitute what Einstein calls a cosmic religion.

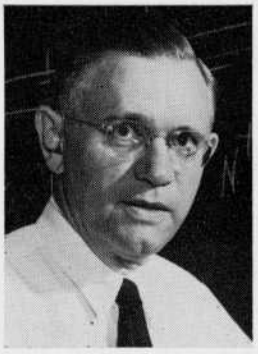
If scientists are to render effective aid in resolving cultural conflicts, they must find means of overcoming the handicaps of specialization, i.e., they must strive to have broad knowledge and wide interests. There can be no question, of course, of doing away with specialization. Scientific problems are usually very difficult and are rarely solved except by prolonged labor of scientists who have spent years studying a particular field. Specialization is also dictated by economy. Think of the funds that would be needed for equipment if scientists would change their research fields every two or three years! Actually, I believe that the evils of specialization have been exaggerated. Competent work in most research fields requires a wide range of knowledge far transcending the field in question. One sometimes hears critics deplore the fact that science is being split up into more and more minute subdivisions. What the critics overlook is that each of these subdivisions has generally far greater content than the parent science had a few decades ago.

So much for our responsibility for cultural integration.

During the first World War the British physicist Rutherford once missed a meeting of a war research committee. He apologized for his absence in a letter saying that he had been busy with experiments in which he seemed to have split an atomic nucleus. "If this is true," he added, "it is more important than your war." Rutherford had knocked a proton out of a nitrogen atom, and his remark referred only to this important advance in basic nuclear physics.

Some twenty years later, Hahn and Strassmann in Germany obtained some puzzling results by bombarding uranium with neutrons. The Austrian Jewess Lise Meitner, who just then had to leave Hitler's Reich, interpreted these results as evidence for a splitting of the uranium nucleus in two nearly equal parts, and calculated the large amount of energy that should be released in such a process. Her idea was brought to this country by Bohr in January 1939, and he and Fermi recognized the possibility of producing nuclear chain reactions with enormous releases of energy. This was accomplished in December 1942, and the first atomic bomb was exploded in July 1945. No events have added more to the responsibilities of scientists.

The first public evidence that the scientists who had developed the atomic bomb were ready to assume their new responsibilities was an article "Science and Civilization" published by Bohr on August 11, 1945, four days after the destruction of Hiroshima, in the *London Times* and also in a Danish newspaper. Bohr wrote in part as follows: "Civilization is presented with a challenge more serious, perhaps, than ever before, and the fate of humanity will depend on its ability to unite in averting common dangers and jointly to reap the benefit from the immense opportunities which the progress of science offers. . . . In the great task lying ahead, which places upon our generation the greatest responsibility towards posterity, scientists all over the world must offer most valuable services. Not only do the bonds created through scientific intercourse form some of the firmest ties between individuals from dif-



ABOUT THE AUTHOR

Since Dr. J. Rud Nielsen, Research Professor of Physics, came to the University of Oklahoma in 1924, *he has made, in the words of President Cross, "extraordinary contribution . . . to the University of Oklahoma through excellent teaching, outstanding research, and your stabilizing influence as a member of our faculty."* "Our Responsibilities as Scientists" *was an address given at the meeting of the Oklahoma Academy of Science, Stillwater, December* 4, 1953.

ferent nations, but the whole scientific community will surely join in a vigorous effort to induce in wider circles an adequate appreciation of what is at stake and to appeal to humanity at large to heed the warning which has been sounded. It need not be added that every scientist who has taken part in laying the foundation for the new development, or has been called upon to participate in work which might have proved decisive in the struggle to preserve a state of civilization where human culture can freely develop, is prepared to assist in any way open to him in bringing about an outcome of the present crisis of humanity worthy of the ideals for which science through the ages has stood."

In this country the first effort of atomic scientists was an attempt to persuade President Truman not to use the bomb but to invite representatives from Japan to a demonstration of its destructive power. When they failed in this, they banded together to work for legislation placing the further development of atomic energy under civilian administration and to promote international control of atomic energy. They founded a journal, the *Bulletin of the Atomic Scientists,* which is now the leading magazine for science and public affairs.

As you know, atomic energy was put under a civilian commission. However, all efforts at reaching an agreement with Russia for control of atomic energy have failed, and East-West tension has increased, while new and more devastating atomic weapons have been developed, not only here but also in Russia. In this dangerous situation, scientists—and especially nuclear physicists —have grave responsibilities.

They must first of all continue to help government and military leaders understand the facts about atomic energy and other physical phenomena relevant to modern warfare. They must try to make clear to these leaders and to themselves what the role of science would be in another world war, and what such a war would be like. Oppenheimer, the American physicist who headed the Los Alamos Laboratory during the war, once said to a government committee: "I can't tell you what to do, but I can tell you what makes sense and what doesn't make sense." The British physicist who developed the radar system used by the RAF, Sir Robert Watson-Watt, wrote three years ago in the *Bulletin of the Atomic Scientists*: "There is no greater necessity in the world of today than a closer understanding by the politician and the citizen of the motives and methods of science, and by the scientific worker of the inevitability of politics and the responsibilities of citizenship."

In a time like this, scientists have an obligation to help make the nation strong. This means, among other things, to see to it that basic scientific research is carried on at a high level and in the most effective manner. It also means, unfortunately, that a large number of scientists must engage in military research and in the development and evaluation of new weapons; for at the present time a country's military strength depends less upon the number of weapons it has than upon their kind and quality. Scientists working on military problems must forego the right to publish and must submit to cumbersome, and sometimes unreasonable, security restrictions.

About one-and-a-half billion dollars annually are spent in this country on military scientific research. There is danger that this kind of research be regarded as a substitute for basic research and that the restrictions appropriate to military research are gradually carried over to basic research. It is up to us as scientists to combat this danger. As Sir Henry Dale, President of the Royal Society of London, said some time ago: "I think that we, as scientists, should make it clear to the world that, if national military secrecy were allowed thus progressively to encroach upon the freedom of science, even if civilization should yet for awhile escape the danger of final destruction, a terrible, possibly a mortal, wound would have been inflicted on the free spirit of science itself, to the immeasurable loss of what it stands ready to offer to a wiser world."

The development and conservation of natural resources and not least the exploration and development of peace-time applications of atomic energy, and of the many by-products of nuclear reactors, will greatly strengthen the nation and are among the most important responsibilities of scientists of many kinds.

Since we can hardly hope to escape war unless something is done to reduce the present world tension, scientists should do what they can toward that end. Science is international. It has progressed by close collaboration of workers in many countries. In my own case, I have worked for a quarter of a century in a field opened up by a dark-skinned Dravidian from Southern India and independently by two Russian physicists. Most scientists have frequent correspondence with foreign colleagues, and many of us have made friends at international meetings. We know that the human race is one species. We know that all men are essentially alike and that all nations hope to avoid war. Although our influence may not be great, we should do all in our power to widen international co-operation. We should support and be willing to take part in any efforts by the United Nations, or other international agencies, that will increase mutual confidence among the peoples of the earth.

While the prevention of war is the most urgent task today, the greatest long-range endeavor should be to create such a world order that lasting peace may become possible. This means first of all to raise the standard of living for the seventy percent of the world's population that are now undernourished. This is a colossal but inspiring program for which many scientists must assume a large share of responsibility.

The first tremendous problem is that of increasing the world's food production by better farming practices and soil management, improved seeds and livestock, insect control, and so on, and by irrigation projects in arid regions. Research on means of making the tropics habitable and productive, on better utilization of the oceans as food supplies, and on the use of algae as a source of protein, should contribute to this end. I understand that significant results may be expected in such a program with rather limited expenditures.

Next comes the problem of developing power resources and creating industries. This is again a task for scientists, engineers, and technicians, and is is a program that will require large capital investments. Finally, there is the problem of markets and trade. While the restriction of trade by tariff barriers may be of immediate benefit to some industries in this country, it will undoubtedly be to our long-range advantage to gear our economy as much as possible to that of the rest of the world and to make whatever adjustments in our economic system that may be required to insure its stability.

Now, you may feel that I have lost my sense of proportion. How can we assume responsibility for the welfare of the entire world?

Frankly, I believe that this country must assume a large measure of responsibility for the welfare of the world if it is to discharge the obligations of the leadership to which it has so recently fallen heir. We must do so out of self-interest, if for no higher reason. If we do not show the poor and hungry nations that we care for them and are willing to help them, we shall not win their friendship, and they may turn elsewhere for leadership. President Truman recognized this when he proposed his Point Four program. Although this program was implemented on a rather small scale and was partly converted into a military aid program, it is doing a great deal of good and is creating a lot of goodwill for this country. I believe that such a technical aid program is as essential for the security

of the United States as atomic bombs and battleships. I am proud that it was headed by an Oklahoman.

The privilege of working in the Point Four program is open to few of us. However, a number of us may have a part in the training of experts or technicians for work in underdeveloped countries, and others may contribute to the solutions of some of the scientific problems underlying or raised by this program. The experts or technicians that we send overseas should not be too narrowly trained. In addition to their specialty, they should know something about the history and culture of the people with which they are to work. They should be able to learn as well as to teach, so that the program can be a give-and-take affair.

There are of course many difficult and perplexing problems connected with such a program. There are problems of timing and of determining the optimum rate of development in each area. The development should not be so rapid as to exhaust the natural resources or to cause too great strain on existing social and cultural patterns. A formidable problem in some places is that of preventing populations whose death rates are reduced by improved medical care and sanitation from increasing faster than the food supply. In India, for example, the increase in population is so rapid that a Government Planning Commission reported in 1951 that: "With all the effort that the First Five-Year Plan will represent, it will be possible barely to restore by 1955-56 the pre-war standards in regard to food and clothing. Increasing pressure of population on natural resources retards economic progress and limits seriously the rate of extension of social services so essential to civilized existence." This is a discouraging statement, not least in view of the low standard of living prevailing in India before the war.

The population of the world has almost doubled in my life time, and now increases at the rate of 23 millions per year. Overpopulation is inevitable, unless the birth rate falls sufficiently with the rising standard of living, as it has done in Europe and in this country. In fact, with the birth rate of the year 1800 and the 1950 death rate, the population of Massachusetts alone would increase in a hundred years to two billions and four hundred millions, i.e., to the size of the present population of the entire earth. Measures may have to be taken to lower the birth rate artificially in many countries. Certainly, the factors that determine birth rate need to be studied carefully by biologists, social scientists, public health experts, religious leaders, and others.

Like most of the other problems created by the impact of science upon society the population problem presents its own ethical dilemma. In his Presidential Address given last year to the British Association the biologist, Nobel Prize winner, and Member of Parliament, A. V. Hill, raised the question of whether it would not be wise to hold back the application of medicine and hygiene from backward people "to keep in step with other parallel progress so that development could be planned and orderly? Some might say yes, taking the purely biological view that if men will breed like rabbits they must be allowed to die like rabbits, until gradually improving education and the demand for a higher standard of living teach them better. Most people would still say no. But suppose it were certain now that the pressure of increasing population, uncontrolled by disease, would lead not only to widespread exhaustion of the soil and of other capital resources but also to continuing and increasing internal tension and disorder, making it hard for civilization itself to survive. Would the majority of humane and reasonable people then change their minds? If ethical principles deny our right to do evil in order that good may come, are we justified in doing good when the foreseeable consequence is evil?"

I do not believe a general answer can be given to this question. My answer would depend on what the foreseeable consequence is, and with what degree of certainty it is known. But these are matters to be determined only by scientific and statistical research.

Although my background in this field is poor, I have tried to read a number of papers on world resources and population. The fact that half of these papers take an optimistic view and half of them a gloomy one indicates to me that there is a great need for basic research in this extensive and complex field. Because of the unique position of this country in the world of today, it seems to me that American scientists should assume a major share of responsibility for this work.

I prepared myself for this talk during the Thanksgiving week-end, and I could not help thinking about how grateful we ought to be for living in a part of the world where hunger is fairly rare and democracy deeply rooted. In addition, we who are members of the Oklahoma Academy of Science have the good fortune of belonging to what is perhaps the most interesting profession. Let us not forget that privilege carries obligation with it.

Before I close, I would like to point out that all three of the general problems I have discussed are essentially psychological in nature. This is certainly true of the cultural conflicts brought about by the impact of science. It is true also to a large extent of the danger of world war. If the less pessimistic resources-and-population experts, such as Lord Boyd Orr, are right, it is true of the problem of raising living standards in underdeveloped countries. This is a unique situation in the history of mankind, and one for which science is responsible. Psychologists, including workers in the new field of social psychology, therefore appear to have special responsibilities, but all of us should recognize this aspect of the problems. As Einstein wrote seven years ago: "Science has brought forth this danger, but the real problem is in the minds and hearts of men. We will not change the hearts of other men by mechanism, but by changing our hearts and speaking bravely. . . . When we are clear in heart and mind—only then shall we find courage to surmount the fear which haunts the world."

I would like to close with a couple of passages from an article entitled "A World I'd Like—An Unprophetic Vision," published in the November 7 issue of *The Nation* by Bertrand Russell, the well-known British philosopher, mathematician, and Nobel Prize winner for literature. In the middle of this article he writes: "I am no prophet, and I cannot tell what mankind collectively will decide. It may decide that it has existed long enough and that it is time to yield place to the animals we have hitherto called 'lower.' This is the view of most practical statesmen and of those who are called realists. People who like myself think that it would be a good thing if the human race continued to exist expose themselves to liquidation if they are Russians and to accusations of fellow-traveling if they are Western."

He ends the article with the following paragraph:

"If, however, the reign of fear can somehow be ended on both sides of the Iron Curtain—or if not ended, at any rate be made less virulent—intelligence and skill, which have never before been so great as they are at the present moment, and which are, in fact, the very cause of our present dangers, may be turned into fruitful channels, and our grandchildren may look back to our time as the last moment of the dark ages from which, as from a long tunnel, mankind will have emerged into the sunshine and happiness of mutual harmony."

Let us do our best to make this vision come true.