Science and Education

By ORLO L. DERBY

State University, Teachers College, New York

Mankind today is paralyzed by fear. Of course, there is the fear of want which has always been with us. There are the age old fears of disease, of old age and death. To some extent these are being overcome by the aid of medicine. But the fear which is everpresent is the fear that someone, either by design or by accident, will begin a war, a nuclear war which will either wipe out mankind or cripple him for years to come. As Bertrand Russell has observed, "scientific technique advances like an army of tanks that have lost their drivers, blindly, ruthlessly, without goal or purpose."

Moreover, the great powers distrust one another—while testing nuclear devices, they are acutely conscious that other powers are requesting the use of such devices, and they contemplate with fear the time that the ability to use such nuclear devices will be widespread, enlarging the possibilities for danger that such use implies.

It is a time when the resurgent peoples of Africa and Asia are becoming conscious of their own destinies, when they are engaged in throwing off foreign yokes, and are embarked upon paths which are new to them and are fraught with danger. The revolutions which occurred in Japan and America many generations ago are now stirring among the peoples of Africa and Asia. And one could not wish otherwise, for the right to be master of one's own destiny and to be free is, in both Japan and America's political creeds, a right inherent and inviolable.

And with this desire to be free, to order their lives as they would

wish, is a determination to use the fruits of science and applied science to raise the living standards of their peoples. No longer will they be content to remain undernourished, diseased, and naked. They have the belief that science and the fruits of science will be able to accomplish this for them. To people such as these, it requires no urging to engage in careers in science. For science means the way out, out of the miseries of exploitation and degradation and despair if not for themselves, then for their children and their children's children.

These ends which are good in themselves come however, at a time when of necessity, the world must learn to get along together. For the world has shrunk, has become a fraction of its old self. In the old days, a man walking from Wakkanai to Kagoshima would have taken several months. Now by train the same ground can be covered in less than two days and by plane in a few hours. When Jules Verne wrote his novel, "Around the World in Eighty Days," he was thought to be a visionary. Now it is possible to do the same journey in about that number of hours.

However, the same applications of science which have so shrunk the world and made us dependent upon one another, have also produced the means for annihilating us and wiping out the races of man on the earth forever. That is, the same science which can eradicate typhoid fever and save millions through the uses of antibiotics, can also operate to be the final and complete scourge of mankind. How did this situation arise?

Developments in science have led the way¹⁾.

In the year 1000 A.D., life to all intents and purposes was controlled by the Church. A hierarchy existed in all life. At the top of all was the Pope, the supreme spiritual father of all Christians. A man owed

1) Rugg and Withers, *Social Foundations of Education* (New York: Prentice-Hall and Co., 1955) p. 329 ff.

loyalty to the Church in the same way as he owed loyalty to his lord on whose land he lived. Feudalism was the order of the day. Each man knew his place and was secure in the belief that if he lived a moral life, that he would be rewarded in heaven.

In Japan, likewise, this was the period of the founding of the Kamakura Shogunate. Feudalism too was the order of the day in Japan. In both Japan and the West, there were periods of strife, of civil wars. On the whole, however, the society was an ordered one and each man knew his place in it.

It was obvious that the world was the center of the universe. The sun revolved around it, and the stars were placed in the heavens to light the darkness of night. This convenient system was overthrown when Galileo and Copernicus discovered that the sun and not the earth was the center of our universe. That this was upsetting to the current conceptions of the world, was evident when they were forced by the ruling authorities to deny that the sun was the center but that the earth was really the focal point of the universe.

Natural laws and the universe

Of course, Newton carried on the investigations of science and enunciated his famous law of gravity. Men of the seventeenth century conceived of science as the discovery of natural laws which governed the universe. It would be possible, they felt, by the orderly progress of investigation to gradually unfold the whole tale of the universe. To Newton, the universe had been set up like a gigantic watch to function through the applications of certain natural laws, like the law of gravity, and all that was necessary was to discover these laws and their applications. The world, which was overturned by the discoveries of Copernicus and Galileo, was reestablished by the discoveries of Newton. True, it was more of a mechanical world, but it was an *orderly* universe. The universe was neat and closed, not of course, dominated by a hierarchy of the Church, but a universe in which men of science directed them-

selves toward the gradual unfolding of the pattern of the great Machine.

One would imagine that men of philosophy and religion would have been more affected by the discoveries of science. To some extent they were. God, if He seemed more remote, at least existed as the original Architect of the Great Scheme. Of course, the ordinary man was little affected by these discoveries in science—to a large extent he was concerned by the struggle to earn his daily living, and saw little necessity for changing his philosophy of life or the principles of his religion.

The comfortable view that if all the secrets were not discovered, at least some day they would be, was rudely upset by the discoveries made in the early nineteenth century by the investigators in electricity and electromagnetism. According to Newton, force was the attraction of one body for another and the direction of energy was exerted in a straight line through the centers of the two bodies. But Oersted and later Rowland questioned this explanation of energy and force, since they found that the direction of force in a magnetized needle placed in a coil of wire was away from the direction of force as exerted in the electrified wire. That is, force was not exerted in the direction one might expect from Newtonian mechanics, but in the opposite direction.

Other discoveries led to the view that all forms of attraction and repulsion were actually due to electromagnetic force, which operate in terms of waves which surround a central body and constitute a field. This field influences other bodies which come within the field.

With the work of Rutherford and Bohr, a totally new view of matter was postulated which viewed matter as a miniature solar system with positively charged protons as a nucleus and negatively charged electrons revolving about them. Matter became energy and energy became matter. Apparently there was no difference—the conception had to be matter-energy, not matter and energy. Moreover, it was not possible to predict with absolute certainty what would be the behavior of matter-energy, but only in terms of possibilities and probabilities. With Einstein, this viewpoint was further advanced by his great synthesis of relativity.

Everything apparently becomes relative—relative to time and to our point of reference.

With the discoveries of Chadwick about the neutron and Hahn and Strassman in the breaking of the atom of uranium by bombarding them with neutrons, the atomic age was ushered in. And in 1935, our distinguished colleague, Professor Hideki Yukawa, postulated the existence of the meson, a fourth particle of subatomic matter, which, in some way serves to provide cohesion for the nucleus of the atom.

Science affected all disciplines.

The rest of the history we are only too familiar with. The use of the atom bomb in World War II, over the protests of many American scientists, the postwar armaments race, and the expansion of the peacetime uses of atomic energy are known to us all. What perhaps is less well understood, is the change which the history of science has brought about in not only the field of technology and applied science, but also in the fields of psychology and philosophy, in sociology and history, indeed in all the humanities as well.

For example, in psychology, the older mechanistic view of behavior as being merely the relationship between the stimulus and response, has given way to the field, or organismic conception, in which behavior is determined from the organization of the field and the responses of the individuals in the field. Behavior has been made much less predictable, and much more dependent upon the individual concerned. The key role of insight, of creative thought, is much more prevalent than formerly.

Modern anthropology and sociology has postulated the key conception of the culture, in itself a group creation. Anthropologists and sociologists have studied culture through living with the actual culture groups, in order to study the interaction between the individual and his culture.

In economics, the views of Smith and Ricardo and Malthus have given way to a less rigid and more general theory of economics which emphasizes the influence of economics upon the whole group or society

involved. Economic change involves flow of income through the whole economic system rather than just price or production which was the earlier view.

It would be difficult, however, to find a field in which change has not been present. The views held in modern science have influenced every facet of modern life.

The present situation—society marked by cultural lag

So far, we have been looking at the development in the field of science and have tried to show how the development of science has affected every phase of modern life, from theories in the more scholarly fields to the everyday ways men have of living together and the means by which they make their living.

While living in an age made pregnant with untold possibilities in the realm of material progress, his institutions are geared to an age when horses drew carts at ten miles an hour. To cite only one instance, we have the possibility of almost limitless production in the material world, but our distribution of goods still relies upon the concept of supply and demand. With automation, we can go far toward eliminating the drudgery of hard labor from mankind, but we still talk in terms of so much pay for so much work.

And this cultural lag is present in all fields of law and customs. Our legislators insist that scientists give them answers in terms of black and white—given the explosion of so many nuclear devises, what will be the effect upon future generations. We talk in terms of right and wrong in our courts—stealing is wrong, therefore many sociologists find that they are given the impossible task of trying to better social conditions when handicapped by judges who know only the right and wrong of laws. The scientist cannot give black and white answers because he realizes that answers are in terms of trends and probabilities rather than in terms of good and bad, right and wrong.

And it would also be honest to admit that some scientists are some-

what less than perfect in this regard. Many of those of my own acquaintance who pride themselves upon their scientific behavior, tend to be scientific only when in the laboratory or study. In regard to those problems which they as members of society should have some valid opinion, they often express the most paltry and unscientific opinions—the opinions of the man on the street ! They either do not know of the advances made in any fields but their own, or by training and experience they are oriented away from the consideration of these problems. It may be that extreme specialization has made them unaware of the society and social conditions under which they live and work. It is possible to so work in one's own narrow cell that one forgets the social implications of his work. Thus, many more scientific personnel are being employed upon making automobiles attractive, upon improving the taste of foods, than are engaged in medical research. The scientist must and should be, as all other citizens, complete men who have a balanced view of life and realize the possibilities and limitations of their work.

What this means for education

If there is a serious lack of understanding of the methods and purposes of science and further, if there is a serious cultural lag, to some extent the remedy may be found in the use we make of the educational system.

First, with respect to the whole educational program, we have operated under a handicap because many of our teachers, particularly those trained under less demanding certification requirements have been unacquainted with the broad view of science of which we have talked. Not only have they not had enough specific training in science itself, but they have not had an orientation into what effect science has had upon the conditions of modern living. Some have not liked science as a discipline and they have no enthusiasm for it. It goes without saying of course, that unless they have the enthusiasm for and love of science itself, that they are poorly equipped to awaken an interest in students.

There have been other drawbacks to the teaching of science itself.

Many students regard science as inherently difficult. For the same expenditure of effort, they get much less returns in terms of grades, than they do in other disciplines. Science teachers in some cases have been much more interested in judging their courses in terms of the number they fail than in the numbers of students in whom they have been able to awaken a love of science. If we need this widespread diffusion of knowledge of science, then we must have a change in attitude on the part of some science teachers. Conscientious students in high school who are interested in making a good record for entrance to college often think twice before taking any work in science beyond the barest minimum.

A question often recurs with insistence in these days. It is this. Should the required program in science be enlarged for the mass of students? At present, one or two years of science are required for entrance into most general college programs. It would seem for those students who are not going to become scientists, that there needs to be an acquaintance with not only scientific principles and facts but particularly with scientific method. This may mean not additional courses in science, but a change in emphasis on the courses being taught. There needs to be much more emphasis upon the generalizations in science and upon the applications to the various phases of modern life. We need the facts and the subject matter of science—we also need knowledge of the place that science plays in modern and world society.

Progress is being made in America with respect to the growth of interest in science in the schools. Last fall, the numbers of students enrolled in science and mathematics was the highest in the country's history and for the first time since 1910, the percentage of students enrolled also increased slightly. From 1954—56, the percentage of students in high schools who took biology increased from 72.6% to 75%, in chemistry from 31.9% to 34.6%, in physics from 23.5% to 24.3%. To be sure, this is a modest increase, but it is an increase, and it is heartening, particularly in view of the shortage of qualified science teachers.

Now this has been good, but we should not lose sight of the fact that the all around growth and development of the complete man must be kept foremost in the education of all citizens. We need to pay more attention to science and scientific method, but we must also remember that no field, in itself, provides a complete education.

The training of the scientist

For those students who are going to become scientists, we need to insist that the only valid excuse for science and scientific method lies in the fact that it helps in the world of men—that it does not exist of and for itself, but rather it is a creature of society and ultimately, responsible to it. This does not mean that every discovery in science must have an immediate application beneficial to society—far from it. It does mean that the remotest branch of pure science must be conscious of its kinship with society. Furthermore, we must insist that scientific decisions, as apart from scientific discoveries, have moral implications and cannot be taken without full regard to a human system of values.

Second, the training of the scientist is often a narrow and constricted one. Since he is often responsible for a tremendous acquaintance with a relatively small field, he often in his education tends to neglect the humanities and other fields which will broaden his view. And the educational institutions themselves have often been responsible for this situation. Degree requirements have often emphasized a narrowness of interest—and professors who are outstanding in their specialities, have made their requirements so rigorous, that there has been small opportunity to engage in any of the broadening and integrating disciplines. Of course, in the better scientific schools, there has been a strenuous effort to remedy this situation, but there remains much that needs to be done.

Third, we need to employ the principle of integration much more in all our higher educational institutions. Placing both scientists and non-scientists in the same classes together in the humanities, emphasizing

core courses and problem courses in modern civilization, engaging in interdisciplinary research, establishing history and philosophy of science courses will do much to aid in the problem of seeing common social problems in a common light.

There are many obstacles toward the achievement of such goals as we have outlined here. Every educational institution has its full quota of departmental chairmen who are jealous of their own courses of training. Rivalries for power, the limitations of one's own background of training mitigate against the common view of a common problem. Often administrations are frankly discriminatory in their attitudes, favoring one kind of training as opposed to another. But many institutions have established such broader systems of training and more are doing so, year by year.

The training of teachers

I could not close without a special word about teachers and professors, for my life has been given to their training. Of course the key in any educational system is not the buildings, or equipment, or even the money available. It is the existence of a devoted and often self effacing group of teachers who devote their lives to the education of the young. If you wish to make changes of the kind we have discussed here, it is necessary to secure teachers and professors themselves who have this broad and comprehensive point of view. In my country we have seen the exodus from teaching of thousands of well qualified teachers and professors in the last ten years. Many of these have been majors in science and mathematics. They have gone into research positions in industry, where the financial rewards have been considerably greater. One vice president of a large corporation recently criticized the schools for the mediocre job they were doing in the field of science—his own corporation and others like it had, of course, hired away from their instructional jobs many of the teachers of science and mathematics!

Good talent in teaching must have adequate compensation, and it

must have dedication for the job. Money alone in the form of high salaries will not accomplish everything, but it will aid in securing that high quality of person whom we want most of all in teaching.

I'm afraid that I have bored you with an overlong speech. I am reminded of what Basho, the great poet of haiku, once said to an overeager student of his: "Seek not to imitate the ancients—strive rather for what they strived for." The pursuit of truth, whether in science or poetry, is an arduous one but we have the assurance that others have gone the way before us themselves seeking the truth. In such a spirit, we can go confidently forward.