Omega
II (2003)1, 79-87

Science, Technology and Society[1]

- D. K. Rai[2]

This paper is an attempt to study the inherent nature of science and technology and its impact on society in order to pose certain important ethical questions in a contextual framework. First of all, the author tries to dispel some of the popular incorrect and unjustified beliefs and expectations concerning science. He points out that science and society influence each other. Furthermore, science and technology are a two-edged sword. All these considerations necessitate the introduction of ethical principles and values to make sure that science and technology do not lose sight of their original goal of achieving human wellbeing.

- Editor

Our age is in many respects a scientific and technological age. Our lives are greatly, both extensively and intensively, affected by the developments in science and technology. While on the one hand these handmaidens of the human mind and creativity have created a world in which natural forces have, to a large extent, lost their terror for humanity, they have also given birth to human-made terrors of unimagined severity. In this paper an endeavour has been made to present a somewhat broad perspective on the inherent nature of science and technology and their impact on society, with a view to pose the ethical problem in a contextual framework. The perspective and the presentation is a personal one and may contain certain controversial and not generally accepted argument, and I must be excused for the same. Although ethical judgments are usually regarded as universal, meant for all, personal viewpoints may still have some value and relevance.

Both science and technology are the products of the human mind which has through its course of evolution developed an urge to know and understand its environment. This urge might have had its origin in the need to survive, but, as many researchers have now come to believe, even language developed not primarily as a means of communication but also as a device to make images of the world around us. These images permitted the human species in the course of evolution to develop a capacity to recreate the past and hence invent the future. In fact, it gave us the power to realize our existence in time without which all concept of a society would be futile and worthless.

This in itself, and in view of its effect on the utilitarian view of ethics, may be a subject of independent discussion, but for our purpose it is sufficient to realize that our mental capacity to disassemble an event has given a great fillip in the development of science and technology.

Initially science, technology and in fact all knowledge (history, arts, philosophy, etc.) were one, and the same person engaged in the studies on all these fronts. However, later on a certain separation of roles has taken place. The urge to understand the natural phenomena taking place in our vicinity, rain and rainbows, thunder and lightning, day and night, movement of the stellar firmament, etc., all were grist to the mills of the human mind. Science originated from this grinding. Technology is essentially the use of scientific knowledge for the benefit of humans. However, this should not be taken to mean that technology always follows science. The understanding that rolling friction is much less than sliding friction came much later, but the use of the wheel for locomotion is one of the most important technological feats of the primitive people. Later on as science became more formal and different, the relationship between science and technology became more intimate, and consequently complex.

Let us first spend a few minutes on the nature of the scientific progress. The classical scientific method involves three identifiable steps - observation, hypothesization, and lastly controlled experimentation. It is assumed that observation and accumulation of data provide the impetus for the formation of a viable hypothesis. A scientifically viable hypothesis is not so general that it loses its specificity to the problem at hand, nor is it so specific that its applicability is limited to one specific problem. Moreover, the hypothesis should be falsifiable through an actual or *gedanken* Experiment (thought experiment). This falsifiability is an essential characteristic of a scientific hypothesis according to Karl Popper, a philosopher of science. The controlled experimentation provides verification or confirmation of the hypothesis, but it must be emphasized that this verification is within certain ranges of the variables involved. No amount of experimentation can finally prove a theory, but a single deviant experimental result can disprove it. The scientific theory - a hypothesis which describes a vast range of phenomena reasonably well is usually raised to the status of a theory – is thus always only an approximation to the truth. Science approaches truth asymptotically, never completely.

There is often a misconception in the minds of the lay public about the absolute validity of a scientific result. The public often believe that the result of a scientific study has universal validity, but it is not true. Despite the claim to the contrary, every scientific study is limited by the experimental constraints, and the result may be valid only in that limited range. Scientists also often do not try strongly enough to dispel this myth for various reasons. This is one of the areas where introduction of ethical studies in the curricula of science and technology would serve a very valuable purpose.

Another misconception about scientific progress is that it takes place in a logical, linear and almost foreseen manner. This is also not true. Most of the momentous discoveries of science have involved essentially a new way of looking at phenomena which were supposedly well understood earlier. Thus Newton was the first to see an analogy between the fall of an apple and the orbital motion of the moon, thereby at one stretch increasing the range of human understanding to regions which were till then regarded as ‘celestial.’

One can give numerous examples of such illuminating insights, which are to a very large extent intuitive and form the content of what Francois Jacob has termed ‘night science.’ The name is very apt because the published literature of science usually gives no inkling of the mental struggle that the scientist has undergone prior to his/her sudden insight and illumination. In this process of discovery a scientist is functioning almost like an artist or creative writer who creates an image of the world from his/her own mental images. It is for this reason that Sri C.V. Raman corrected Homi Bhabha who while presenting a portrait of Raman drawn by himself (Bhabha) said “a scientist painted by a scientist.” Raman’s statement was “no,” “an artist painted by an artist”. In fact Raman held that “science is a fusion of man’s aesthetic and intellectual functions devoted to the representation of nature. It is therefore, the highest form of creative art.” We can thus conclude that science attempts to fashion a model of the world as we see and experience it. There is no insistence, as there cannot be, that this model is the true reality. It is at best an approximation to the reality, and at worst a subjective description of the universe.

As science has progressed, its objects of inquiry have become farther and farther removed from our everyday life and experience. From studying objects of sizes comparable to human dimensions we have progressed, on the one hand, to dimensions of 10^{-33}cm (the size of the nucleus) and shorter, and, on the other, to objects of the size of stars, galaxies and even clusters of galaxies. Even in the area of life sciences, from studying species, whole animals, organs, etc., we have climbed down to the level of molecules and elementary particles. This has become possible only due to the developments in technology which have extended the range of our senses to an astonishing degree. Each new technology has permitted new questions to be asked, and every new solution has added to the further development of technology. This mutual dependence precludes a separation between science and technology as far as their impact on society is concerned.

Society impacts on the development of science and technology in a variety of ways. First and foremost every scientist/technologist is a member of the society, and hence is imbued with the culture and social needs and aspirations of that society. A society which does not permit its members to question authority is not likely to encourage the free imagination needed for progress in science and technology. The so-called dark ages in the European civilization was one such period in history. Both arts and science seemed to come out of their shell and almost at the same time, when a desire to challenge the past beliefs and value system emerged. It is not only the social context that is important, even the scientific milieu of the society plays a crucial role in the manner and rapidity with which science progresses. The emergence of quantum ideas in the first quarter of the 20^{th} century and the growth of molecular biology in the second half of the same century are examples of this effect. Of course, one must not minimize the role of accidental discoveries which can also open up entirely new vistas of research - the discovery of X-rays being one such example.

Society and its administering body, the state, also often try to direct the course of science and technology along avenues of perceived interests. Much of present-day science and technology is being directed in this manner. Very often this is not a very successful process, specially in the pure sciences. Pure scientific research in its fundamental sense is unpredictable. It is driven by an urge to understand, and the results of any experiment are definitely not known in advance. Technology is more amenable to direction from outside as long as the basic scientific problems are well known, and at least in principle solved. The American programme to land a man on the moon in a decade was an example of a successfully directed technological feat, but the same country's effort to find a cure for cancer in 10 years in the 1970s came a cropper. Since technology is a source of financial gain and power, often the direction of its growth is based on considerations other than the human good. The recent decision of the prestigious medical journals to verify the results of the drug testing programmes conducted by the pharmaceutical companies before recommending public use of the drug is a repercussion of this feeling.

Science and specially technology for a long time have been regarded as a panacea for all the problems of society. Our own Science Policy Resolution adopted by the Parliament in 1956 reflects this view of science. However, during the past several decades science and specially technology have come under attack for allegedly degrading our environment, creating a mechanization of the human society, creating weapons of mass murder and also as disruptive of the moral and ethical fiber of society. The symptoms of sick environment both physical and human are very obvious and hardly need any repetition. But is it proper to blame only or even mainly science and technology for the same? An apologist for science would probably answer this question with an emphatic no, while many would give an equally resounding yes as an answer. The truth is, as usual in such circumstances, somewhere in the middle with both answers being partly correct.

Let us see what a few scientists and technologists say about their vocation. Abdul Kalam has stated "Science is a passion - a never ending voyage into promise and possibilities." Erwin Schrödinger, the person who helped mightily in the development of the presently accepted worldview of the physicists, states: "What is the value of natural science? Its scope, aim and value are the same as that of any other branch of human knowledge - it is to obey the command of the Delphic deity- "Get to know yourself."

Albert Einstein had advised his fellow scientists not to forget hat "the betterment of the human condition is the sole purpose of science." Where have science and technology gone wrong so that they are being blamed?

As stated earlier, technology which seeks to apply knowledge for practical purposes is very often a source of power and pelf, and hence any one may like to use it for personal or group gain. This is the place where misuse of science and technology begins. Use of scientific knowledge and technological powers for state purposes is another area where misuses occur. Let us consider a few examples. Eugenics was developed as a theoretical idea in the early days of the 20th century and gained an enormous momentum. The theory which was later proved to be erroneous contributed, according to many scholars, towards the hardening of the Nazi racial prejudice, and Hitler and his followers brutally resorted to it in dealing with the Jews and the gypsies. Lest we forget even Plato and Franklin were to a certain extent believers in the false myth of eugenics, though they lived much earlier.

Atomic energy is one area which is usually regarded as the clinching issue as far as the debasement of moral and ethical values is concerned, chiefly because of the role of scientists and technologists in creating the atomic bomb. It might be interesting to describe in brief the main steps in the drama. Ever since the discovery of radioactivity scientists felt that there was a lot of energy hidden in the interior of the atoms. The energy was measured, but as late as 1938 just before the discovery of fission by Hahn and Strassman in Germany, even as perspicacious a person as Rutherford dismissed the idea of ever using this energy as “moon shine.” Then in 1939 came the discovery of atomic fission, in which the nucleus of uranium was found to break into two almost equal-sized parts with the release of a vast amount of energy. The crucial fact was that the fission also released neutrons which could under suitable conditions cause more fission. The idea of chain reaction was thus developed. Hitler had come to power in 1933 and in September 1939 attacked Poland, thereby launching the Second World War. For almost two years his armies were irresistibly marching from one victory to another. Their attitude towards the so called ‘non-Aryans’ had by then become well known, and there was a genuine fear in the minds of many scientists, specially those of European origin, that if he could get hold of a superior weapon, there would be no hesitation in its use. It was in a situation so fraught with real and imagined dangers that Einstein was persuaded to write his famous letter to President Roosevelt recommending a heightened research programme to develop, if possible, military weapons based on atomic fission. It is a tribute to the ingenuity of the persons involved and the massive technical and financial inputs that the mission succeeded. In July 1945 the first test was held in New Mexico and the scene was awesome.

Jungke has described how Oppenheimer was reminded of the Gita wherein Arjuna was at first blinded by the glory of the Lord - described as ‘brighter than a thousand Suns.’ It is however poignant and probably more reflective of the attitude of a scientist that while many were jubilant at their success, Fermi, standing about a kilometer away from the test tower, was dropping small pieces of paper to the ground to estimate the power of the blast. Once the bomb was made, many of the same scientists had second thoughts about its use in war, and suggested a demonstration on an uninhabited place. But by then the decision was no longer in their hands. However, its scar remained in many psyches. The withdrawal of many of these scientists from the thermonuclear bomb development programme in the late fifties, and from the star war program in the seventies and early eighties, was probably a reflection of the same feeling. They probably felt that their participation in the original Manhattan Project was justified by the exigencies of the situation only, and was not a norm to be followed.

"Atoms for peace" became a slogan in the mid fifties as atomic energy was regarded as a source of plentiful power. Many reactors were built and began to operate. Nuclear energy started to contribute a significant part to the national grids in many countries. However, in the initial euphoria many of the safety regulations were relaxed in favour of economy. Accidents which had taken place, but had been kept secret, came to light, and with plentiful oil and coal available these combined to create a ground swell of opposition to nuclear power. Just as the euphoria in the fifties was unjustified, it is not far off the truth to state that the opposition was also not fully justified. All the accidents that have so far happened in association with nuclear power have claimed much less lives than in the mining and use of coal for the generation of power. Alternative sources of energy despite continued and increasing spending are not able to contribute significantly in the near future. Recourse to nuclear energy, specially in countries poor in fossil fuels, is essential if living standards are to be raised.

This brings us to an essential dilemma. Science and technology are essential for the wellbeing and continued improvement in the living standards of humans. But their indiscriminate use can be disastrous. Without refrigeration perishable commodities cannot be stored and transported from the point of production to consumers. But refrigeration was till recently dependent highly on fluorochlorocarbons shown to be responsible for the damage to our ozone shield. Synthetic fertilizers are needed to produce sufficient food for our burgeoning population, but their use is polluting our soils and waters. Biotechnology and genetic engineering promise to create a revolution in agriculture and medicine, but are also capable of creating disasters.

What is the path to follow? We cannot stop the growth of science and technology as it is inherent in human nature to try to know, to understand, and once known to use. Should we be afraid of this new knowledge? Is there something akin to forbidden knowledge? The answer to both these questions must be no. Knowledge is not dangerous, ignorance is. Our rishis have taught us that knowledge is that which liberates. What is needed is that application of knowledge has to be carefully made, and its limitations must be kept in mind, and this is where scientists have a great responsibility to society. They must outline clearly and truthfully the limits of their knowledge. The final decision on use is, of course, to be made in a democracy by society. In this connection one of my associates Br. Karunanda has drawn a certain parallel between the path of self knowledge in the old spiritual tradition of India and that followed by modem science. Both are attempting to understand the secret of the universe. The former - spiritual seeker - proceeds through the path of asceticism overcoming his desires and undergoing penance. The seeker, according to our scriptures, acquires many miraculous and semi-divine powers in this process. However, if he becomes enamoured of these powers and lusts after them, he falls down in the quest for self knowledge, and unless he recovers in time (essentially through the grace of the Lord), he is condemned to ignorance. The scientist in his continuing endeavour to understand the world around him/her has acquired a lot of knowledge which can be and is being used for power and pelf. But the scientist has to remain ever watchful lest he should lose sight of his ultimate objective and gets enmeshed in the results of his midway achievements. This is probably the right note to strike at this moment.

Notes

[1] This paper is based on a lecture delivered in Maitri Bhavan, Varanasi, on October 2, 2001.

[2] Dr. D. K. Rai is professor of Physics at Banaras Hindu University, Banaras, Varanasi.