



SCIENCE AND HUMAN SURVIVAL

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Alvin Toffler, in his book *The Future Shock*, has expressed in a very effective manner the remarkably rapid way that science has come to influence human life in recent years. Toffler divides the period of the last 50,000 years (about which some records are available) into 800 human spans. Thus simple arithmetic tells us that a span of typical human life is of $62\frac{1}{2}$ years. How has man fared over these 800 life spans?

Of these 800, the first 650 life spans were spent in caves. Only during the last 70 life spans has it become possible for one generation to leave records (by writing, pictures etc.) for communication to the succeeding generations. Printing on a large-scale has been in use only during the last six life spans. The electric motor which, in its various forms, plays such an important role in human existence, dates back to barely last two life spans. The key to nuclear energy became available in the last half-life-span and space age dawned just about one third life-span ago.

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These examples illustrate how rapid has been the influence of science in the last 100 years. Not only has the speed been rapid—it is accelerating. On the face of it this seems a happy state of affairs: science is knowledge, knowledge is power and hence man is becoming more powerful in relation to his environment. We may even point out several instances where this power has been used by man to make his life more pleasant and comfortable.

But there is the other side of the coin too! Man has used power for destruction on a massive scale. While making items of use towards making his life comfortable he has started polluting the environment to an incredible extent. By winning the battles over many diseases and thus prolonging the typical human life span, man has let loose many psychological, social and economic problems which he did not have to face before. Indeed, the detractors of science have often given these examples to argue that science poses the biggest threat to human survival.

The cases for and against science can be argued at length. Nobody, however, can deny that the rapid growth of science has caught the human species unprepared. The mental maturity which is needed to assimilate the knowledge provided by science is simply not there. What is required is a massive programme of information, education and projection for the future. This has to be undertaken at all levels, from the so-called illiterate

masses to the so-called planning experts. In the West, conscious efforts are beginning to be made as the realization of the problem sinks in.

In India, and in other developing countries, the enormity of the issues does not seem to have been realized. Since the explosion in scientific progress has come at a time when India is at a much lower level of scientific development than the West, the strategy to be adopted for dealing with the explosion cannot be blindly copied from the West. Fresh thinking is necessary for ideas which will avoid our going through the same painful stages that the more advanced countries are experiencing now.

In this article some of these issues will be discussed, from the wider standpoint of the human species as a whole as well as from the point of view of India as a resourceful but developing country.

Future forecasting in a rapidly changing world is always a hazardous process. A thirteenth century man could well have reasonably foreseen what the fourteenth century world would be like. But could a nineteenth century man have foreseen the present world of space travel, of advanced computers, of nuclear weapons and the like? For us to guess what the world would be like in the next century is therefore an ambitious project. But that is no reason for not doing anything at all. Indeed, as we shall see below, the problems of survival are already with us and taking no action

is tantamount to burying our heads in sand. Future forecasting at least removes the sand from our eyes even if it does not provide an accurate and clear vision.

Growth of Scientific Research

Scientific research, whether pure or applied, is getting increasingly a big money project. In 1919 Rutherford's equipment for his famous atom-smashing experiment could be held in hand and did not cost more than a few hundred pounds. The modern particle accelerator is a gigantic affair; Chicago's Fermilab has a ring of more than a mile's circumference, the entire project costing \$ 250,000,000. This is the price man is required to pay for probing the atom deeper and deeper.

Even the science of 'star-gazing' — astronomy — has grown far beyond the primitive stage of a man on a rooftop with eyes glued to a telescope aimed at the cosmos. A modern Galileo or Tycho Brahe does not trust human eyes but relies on computerised recording instruments. His telescopes are big enough to accommodate several human beings in their tubes. A radio astronomer too has devised the technique of very long baseline interferometry (VLBI). Technically a VLBI telescope extends to several thousand miles. Not content with observing from the *terra firma* the optical astronomers are looking forward to a satellite based telescope orbiting the Earth.

All this costs money. So does research in biology, medicine—and

even the purest of pure subjects, mathematics. The budgets can be large enough to be beyond the range of individuals, private organizations and even nations.

Faced with such huge budgets for scientific research, nations are inevitably asking the question: "Do we really need to support such expensive research?" It is significant that the advanced nations, for various reasons including rivalry, material gain, security etc. have thought it fit to continue the support. As money cost grows, naturally it becomes necessary for the scientists to be socially more responsible. They have to ask the questions: (i) is our research likely to lead to dangerous effects on the society?, (ii) is it good quality research? (iii) is the potential discovery likely to raise more problems than what it is intended to solve?.... It is becoming increasingly necessary to have a meaningful discussion between the society, the planners and the scientists.

It is said that when Queen Victoria went to see the experimental laboratory of Michel Faraday she asked him what was the practical use of his experiments. "Your Majesty," Faraday replied "Do you ask, of what use is a new born baby?"

Pure research often provokes the type of question that Queen Victoria asked Faraday. And like the answer given by Faraday, the question needs to be answered by the scientists firmly and unapologetically. Even in a developing country with severe strains on its bud-

get, good quality pure research is never a luxury that cannot be afforded. It is a necessity that the country cannot afford to miss. Without it, will go the stream of original ideas, the habit of original thinking and the independence in research so essential to every country. As Homi Bhabha put it on the occasion of the inauguration of the new building of the Tata Institute of Fundamental Research :

“.... By fundamental research I mean basic investigations into the behaviour and structure of the physical world without any consideration regarding their utility whether the knowledge so acquired would ever be of any practical value. Nevertheless, the support of such research and of an institution where such research can be carried out effectively is of the greatest importance to the society for two reasons. First of all, and paradoxically, it has immediate use in that it helps to train and develop in a manner in which no other mental discipline can, young men of the highest intellectual calibre in a society into people who can think about and analyse problems with a freshness of outlook and originality which is not generally found. Such men are of the greatest value to society, as experience in the last war showed...”

Pure research takes us to the frontiers of knowledge, to unexplored domains, often to blind alleys. It is always a hazardous process to

put a price on knowledge. Even from hindsight can we put a value on $E = mc^2$ which came out of Einstein's note books when he was a clerk in the patents office? Work on astrophysics of the interior of the Sun first demonstrated that nuclear energy can be harnessed : something which still eludes man on the Earth. Today's computer technology originated in the purely scientific laboratory investigations into transistors, semi-conductors and the miracle chip. How do we evaluate the monetary worth of such investigations?

Man has been endowed with the gift of curiosity. Under the discipline of scientific outlook he gives vent to it through pure research. To suppress pure research for the mistaken reason of want of funds is to kill this nature's gift to man. Pure research of good quality, funded intelligently costs a minute percentage of the gross national product. Where waste occurs is in funding repetitive work, in not assessing the quality of the work and in not keeping periodic checks on its progress.

I have advocated the need for support to pure research in such outspoken terms because I find a peculiar apathy or lack of conviction among the leading scientists of India to speak out plainly and without any apology. Even a poor country like India can and must afford a few ivory towers of pure research.

As to applied research, the issues become much more wide and clearly defined. There are a num-

ber of specific problems before mankind which pose threat to its very survival. I can see no other remedy except an intelligent control on the application of science and technology. I mention a few of the more important danger areas.

Automation

The increasing use of computers and other machines has no doubt simplified human existence. At the same time it has led to socio-economic problems.

The economic problem is clear: machine makes man redundant. How do we employ the men made redundant by automation? Usually this question is looked at negatively: because we cannot afford unemployment we must not introduce automation. There is also the positive aspect: we can avoid redundancy if we expand the production so that the same number of men, now aided by the machine can produce more.

In a developing country like India there is plenty of scope for expansion. Given an increased capital more products can be produced; but who can afford to buy them? The majority of buyers are poor and will remain poor unless productive work is found for them. But as we just saw, increased production leads to a surplus of goods because there are no purchasers. Thus there appears to be a vicious circle which cannot be broken unless we give up the notion of the country as an isolated economic entity. Increased capital may come from abroad and

surplus products may be sold abroad. This may sound scientifically reasonable but very often the political and ideological factors interfere with such a solution.

The second problem which is already being faced by the affluent countries is a social one. With increasing free time due to automation, even a well-to-do man with a job does not know what to do with his free time. 'An idle man's mind is a devil's workshop'. The mental uneasiness is often translated into insomnia, unstable homes, drug addiction etc. It is ironical that even with the availability of so many harmless leisure time activities man has to face these problems. The increasing crime rate, especially among the youth in the U.S. and other affluent countries is a translation of the psychological problems of the individual into the social problems of the community.

In India the majority of us are faced with the problem of the daily bread, and are therefore facing difficulties of a different nature. But as our country becomes increasingly technology oriented these problems will increase. Is it not better to find a solution for them when it is not too late rather than be overtaken by them as in the advanced nations?

Earth Resources

The Middle Eastern war of 1973 brought home to most industrial nations how dependent they are on oil. Although the Arab oil embargo was of a temporary nature, the question arose: 'how long is the oil supply on the Earth going to last?'

Experts differ in their assessment of the oil reserves. On the basis of known reservoirs, however, most would agree that the problem will become acute in the next few decades. There is, of course, the possibility of extending the reservoirs by recovering oil from under the sea. Here we do not know what the potentialities are and whether under-sea reserves (if any) will be accessible before the proven reserves run out.

Naturally experts are advocating energy conservation and the search for new energy resources. I will discuss this later. The coal energy may last several centuries but the extraction of coal may become increasingly more difficult as we have to dig deeper into the Earth. More sophisticated technology costing more money will be called for in future. This applies not only to coal but to other materials like copper, iron etc. which have to be mined.

After all, the Earth, in volume and in area, is a finite object with resources which cannot last for ever. And with increased technology the demands on these resources will increase.

A related question is of food. The present food production is barely able to feed the human population. Can it be increased? Certainly we are far from the optimum in this respect. By having all irrigable land under food production, by improving yield per acre, by having many crops per year it is possible to increase food production. A future technology may also provide devices

like artificial rain. It may also be possible to tap the sea-bed for food of a different sort. Non-vegetarian food is an expensive and inefficient way of eating proteins. It may well become possible to replace this primitive way of eating proteins by a cheap artificial and acceptable substitute.

Through such futuristic devices it is possible to think of a world food production of 10-100 times its present value. This appears to be a comfortably large figure but only if we succeed in keeping the world population within reasonable bounds. If the present rate of growth of population is any indication, the future is far from being comfortable.

Population Catastrophe

There is a simple formula for the rate of growth of population:

Increase in the Population per year (I)

= number of births per year (B)

– number of deaths per year (D)

Science has played a role bordering on the miraculous in reducing the value of *D*. Deaths at child births have been drastically reduced; the epidemics have been largely controlled; surgery can save lives which would formerly have been abandoned... The reduction in the value of *D* is reflected in the increase in the life-expectancy of the population. Nowhere has this been more dramatic than in the so called developing countries.

Let us now look at the birth rate, *B*. If one set of parents produces two offsprings and if the life expectancy were constant, then we should expect the over-all population to stay constant. However, if life expectancy increases then *I* will exceed zero. On the other hand, not all adults marry and produce children so that this effect should reduce *I*. Taking into account these two opposite effects it is estimated that in order to keep the population steady the average number of children per family should be slightly above 2 (but less than 3).

Many advanced countries have achieved a zero population growth rate by suitable birth control measures. Unfortunately, the performance is far from satisfactory in the developing countries. Lack of awareness of the problem at the individual level, superstitions, social stigmas and religious dogmas and mistaken notions of economic stability of the family have all contrived to generate a reluctance (and sometimes hostility) on the part of the married couples to accept such birth control measures as are available.

It is ironical that whatever gains are achieved in India (and in other developing countries) by the application of science and technology are washed away by the growing population. The number of children per family exceeds the desirable optimum number in many families, in spite of the economic hardships it imposes on the family members. The danger, however, is not apparent to the common man because it does not seem as catas-

trophic as, say, an atom bomb explosion, or as uncomfortable as the erection of a polluting factory in one's neighbourhood.

In his book 'The Ten Faces of the Universe', Fred Hoyle has given a few calculations of the creeping danger of population growth. It is worth repeating his conclusions.

At present the rate of growth of human population, *I*, is about 2% (per year). This growth is like a compound interest so that the population doubles in 35 years. What would happen if this continued for say 1500 years? Then there would be so many human beings around that there will not be enough oxygen in the atmosphere for more than one breath per person! And if this growth were to continue for the next 5000 years, the total mass of human population would exceed the mass of all the galaxies seen from our largest telescopes. Finally, to push the argument to its ridiculous extreme Hoyle reminds us that the present rate of growth is itself showing signs of increasing (so that in future it will be higher than 2%). If one takes into account how rapidly it is rising then the population will grow so fast that it will become *infinite* in the year 2025 A.D.

The purpose of such alarming figures is not to insist that they will come to pass, but to point out that catastrophic situations are bound to arise in the next half century if intelligent measures to control population are not taken now.

Judging by the growth of science we could expect that cheaper and

socially more acceptable birth control devices may be available in the future. The main problem, in my opinion, will continue to be that of convincing man that their use is indispensable for his survival.

Challenges to Science

What are going to be the challenges to science in the next five decades? Apart from the issues discussed above, the problem of energy will become more and more severe, as the society grows more and more technology-oriented. One indication of this is to ask the following question: "How many times the energy needed for bare survival, does a human being consume?" The primitive man used just the energy for survival: for food, for keeping himself warm and for hunting animals. The modern man living in all comforts of modern technology spends even ten times that energy. Naturally the per capita energy consumption is the highest in the United States, (which is also notorious for wastage of energy), followed by European nations. When the developing countries reach that level of standard of living, their energy per capita will also rise to very high levels. Where is this extra energy to come from?

Science has to provide the answer. Two prospects are tantalizing but remote. Nuclear fusion using heavy water can generate plenty of

energy if the technical problems of containment and pollution are solved. The second hope lies in harnessing solar energy which is more than enough to meet all human requirements for the future. As a source, the Sun will continue to provide energy for billions of years (if modern astrophysicists are right!). However, the utilization of this energy on a large scale still remains a challenge to science and technology. Will these sources be available to man before he exhausts his oil and the easily obtained coal reserves? The outcome holds the key to human survival in the next century.

Scientific research in life sciences is taking man to a stage where he will be confronted with very fundamental moral decisions. How long should the life of an ailing, suffering, nearly dead person be continued? Should genetic research tampering with the origin of human species be carried on? Is it desirable to experiment on the human body and brain to further the interests of science? Should potentially harmful biological experiments (including those for warfare) be carried on in civilian areas? Many of these decisions will require a moral code, an ethics of life and a maturity of outlook which science does not seem to provide. Will man get adequate guidance from his vast store of knowledge — from the ancient wisdom of his forefathers? For therein lies his chance for survival and betterment.