Gandhi Memorial Lecture

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at the

Raman Research Institute

BANGALORE

AGRICULTURE, SCIENCE AND HUMANITY

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I am deeply conscious of the high honour which has been bestowed upon me by the Trustees of the Raman Research Institute in their invitation to me to deliver the Gandhi Memorial Lecture. I still do not feel that I am worthy of the task which has been assigned to me. But I have accepted in all humility because I felt that by doing so I could render my personal homage to the greatest scientist India has produced, Professor Sir C. V. Raman. My talk is in three parts; in the first I will discuss agriculture and food, in the second I will refer briefly to the role of science, and, finally, in the third section I will consider some problems of humanity and how science and education can help in solving them.

AGRICULTURE AND FOOD

Green chlorophyll came before red blood; plants preceded animals on this earth of ours and the green leaf governs the economy of nature. The early history of man is shrouded in the mists of time. But the evolutionary record clearly delineates man's kinship with the animal world and there is no reason to doubt that man and the great apes evolved from a common stock. Henry Bailey Stevens has speculated that man's ancestors, like the great apes, lived in the trees and subsisted on a diet of fruits, nuts and tender leaves. But when prehistoric man descended to the ground he had to become a hunter to gain his daily food.

There was a very long period of time before man by a slow process of domestication of plants and animals laid the foundations of a settled agriculture, so essential for the development of civilization. But the early history of agriculture, like that of man himself, is a matter of conjecture. Archaeologists, anthropologists and others have studied the remains that are found at the ancient sites uncovered by excavations and propounded theories as to what must have been the conditions of human life in those bygone eras. Even about that well-loved flower, the rose, Walter de la Mare has said:

'Oh! no man knows
Through what wild centuries
Roves back the rose.'

In the case of most of our crop plants too, no one knows when they were first cultivated; quite often even the immediate ancestors of these types have disappeared, leaving scope for the writing of many doctoral theses on their supposed origins.

It is truly astonishing that early man was able to do such a remarkable job of plant improvement. As Edgar Anderson has pointed out, modern man, in the 5,000 years of recorded history, has not been able to add a single major crop to his list of domesticates! Thus in the New

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World, maize, sunflower, cucurbits including the gourd, two species of tobacco, three species of Phaseolus, the groundnut, the amaranth and the quinoa had already become cultivated plants before the dawn of recorded history. Similarly, in the Old World, wheat, rice and a great many other economic plants including fruits and vegetables had been developed. It appears that, in the beginning, the tendency was to make multiple uses of plants rather than cultivate them for a single purpose as is often the case in our modern mass-production agriculture.

Thanks to the outstanding contributions of that great Russian botanist, N. I. Vavilov, the importance of collecting and preserving as wide a range of germplasm as possible of economic plants and their wild allies has come to be recognized. Vavilov's life work also indicated that there were some areas in the world in which, as a result of favourable conditions, species and varieties of certain economic plants were found in unusually amazing abundance. These he regarded as centres of origin of our cultivated plants. There has been some tendency recently to question whether these were really the centres of origin or rather the centres of survival of genetically important variations. But whichever view is taken, there is no doubt that these natural gene pools are very important for the immediate and future work of the plant breeders, and everything possible must be done to collect and conserve them before valuable genes are lost for ever.

As every one knows, human beings as well as animals require food in order to live. While plants because of their possession of chlorophyll can, utilizing the energy of sunlight, create their own food, all animals and man either live on plants or on animals which again, in their turn, live on plants. To be in good health the human body requires to be in a state of efficiency, *i.e.*, not in mere passive existence but with the capability to resist disease and to meet other calls upon its energy. Food is a primary necessity and as the Japanese saying points out:

'Even Fuji is without beauty to one hungry and cold.'

Mahatma Gandhi referred to the same fact in the following unforgettable words: "I may as well place before the dog over there the message of God as before those hungry millions who have no lustre in their eyes ..... how am I to talk of God to the millions who have to go without two meals a day? To them God can only appear as bread and butter." In another significant sentence, on another occasion, he said: "To a people famishing and idle, the only acceptable form in which God can dare appear is work and promise of food as wages."

One of the great problems of the present world is that of food supply for the population of the world which is increasing at a terrifying pace. While the developed countries are largely characterized by large farms and adequate resources with which they are able to produce enough food of the different kinds required, in the densely-peopled under-developed countries, there is a continuous struggle to find the means of subsistence for huge populations. In most parts of tropical and sub-tropical Asia the average farmer has a small holding, usually about two hectares, and from this little piece of land without any other resources he has to maintain a family of 8 or 9 or even more persons.

Unless we can find the means of feeding the millions of human beings who already inhabit this earth, talk of other things becomes almost meaningless. Though one recognizes that man does not subsist by bread alone, yet unless the bread is there he cannot exist to partake of the finer things of life. It is one of the tragic paradoxes of our time that while in some countries there is so much surplus agricultural production that food or other useful materials are burnt or thrown away to maintain a high level of prices, or farmers are subsidised not to produce more agricultural products, in large parts of the world there is the most grimly severe under-nutrition and malnutrition. In spite of the fact that man is heir to so many centuries of civilization and so many great religions have preached the brotherhood of man and other qualities, yet those who have the opulence permit the unfortunate people of the poorer countries to starve. While there is money and extraordinary scientific resources to permit space explorations, such resources and such intensive scientific endeavours have not been available to remove the misery of the world.

Agriculture therefore has, as never before, a role of the utmost significance for the welfare of humanity. In the past, in many countries like ours, it occupied a lowly place in the scheme of things. Even among the sciences, agricultural science was considered to be a plebeian sort of science. Its votaries were not as well paid as the others and suffered from various disadvantages. Fortunately, in very recent years, some changes for the better have taken place. In this country there has been some re-organization of agricultural research and education, and already this has yielded results which have enabled us for the present to ward off the threat of famine and given us the confidence to face the future.

We must, however, take serious note of the fact that, even with the best of efforts, after a while there will not be sufficient food unless the rate of population increase is greatly slowed down, especially in the developing countries where the problem is most acute. The urge to reproduce is one of the fundamental characteristics of all living matter and in some forms of life the rate of multiplication is fantastic. According to Dr. S. Pradhan, "It has been calculated that the progeny of a single moth can cover the entire dry surface of the earth to a depth of 80 feet within a period of one year in case all the progeny is allowed to live their normal life. This calculation is on the assumption that a moth lays just 200 eggs and completes the life-history in one month. Both these assumptions are quite normal for a large number of insect species while there are species of insect in which thousands of eggs are laid per female". Compared to this, the reproductive capacity of the human race is quite modest but human beings require much more food per individual and they also have other requirements. Already in many countries we have reached or even somewhat exceeded the safe limits for bringing land under the plough. If we encroach further upon our precious forests and pasture lands, this may lead to dolorous results, changing even the climate of the country fo the worse.

The developing countries have many handicaps to overcome. The soil in many of them is highly eroded and exhausted in its content of major nutrients due to centuries of exploitation. There are many other problems also. But there is also tremendous potentiality. In a

masterly summary, Dr. M. S. Swaminathan, in a paper prepared for a conference dealing with the role of nuclear techniques in agricultural research in developing countries refers to "certain unusual possibilities awaiting exploitation" which are now in sight. These have opened up entirely new vistas for increasing the productivity of irrigated agriculture in the tropics and sub-tropics, which are endowed with abundant sunlight throughout the year, through the developments of scientific multiple- and relay-cropping systems. Then through the introduction of genetic factors for photo- and thermo-insensitivity most crop plants can be made to flower and fruit within a specific period, thereby eliminating or reducing their dependence on seasons and making the introduction of the concept of "productivity per day" possible. Further, considerable advances in water technology and water-harvesting procedures have taken place with the result that the productivity per unit of water can be considerably enhanced and dry-land farming made more remunerative. Again, developments in fertilizer technology and pest-control procedures coupled with the concept of appropriate plant types or architecture have changed many old notions on the genetic ceilings to yield. This in turn has opened up new prospects for re-structuring cropping systems so as to maximize the income from small holdings. Then again, advances in post-harvest technology have made income from agriculture (including horticulture and animal husbandry) more secure and stable. Finally, and most importantly, experience from developing countries which have introduced a synergistic package of new practices in areas where agriculture had remained stagnant for a long time, has clearly revealed that the new technology can serve as a catalyst bringing about rapid change in the outlook of the farming community, provided the technology offers hope for making a substantial jump in yield and income. All this fills us with hope, but as that great wheat breeder and humanist, Dr. Norman Borlaug, has warned, "there is no time to relax".

A modern society requires that there should be, besides food, roads, railways, air-fields, industrial complexes and the like; there also has to be provision for schools, hospitals and other necessary amenities. But if we plan with sagacity, using science both to increase the productivity of agriculture and to slow down the birthrate of the human race, the problems of food supply and raw materials for trade and industry can be assured.

The Role of Science

Science is essentially a quest for truth. Modern science has developed to such a great extent, and at such a tremendous pace during the past few decades, that its results permeate every segment of our lives. For instance, the great advances in locomotion and transport have made the world much smaller, bringing the peoples of various countries closer together. The power of electricity can now be used in so many wonderful ways. But one could go on listing the great achievements of science and one would end up with a most imposing statement which could cover several hundred pages. According to the old Greek legend, Prometheus stole fire from heaven and brought it down to earth for the benefit of mankind, for which he was punished in a terrible way by Zeus. Science, like a modern Prometheus, has brought hundreds of things within the reach of man, helping many to live a life more complete with amenities and comforts

than was possible before. Above all it has made it possible for leisure to be given to men. As long as man was dragged down by the drudgery of eking out his daily existence without the help of scientific tools, he had little time for anything else, and leisure is necessary for man to think and to concern himself with the higher things of life. But even today there are millions of our fellow-beings who do not have leisure. In fact, as pointed out by Bertrand Russell, "the idea that the poor should have leisure has always been shocking to the rich"! We have to see, with so much development in science, that all human beings have the requisite amount of leisure. One does not, of course, advocate all leisure and no work: lives which are devoted only to pursuits of pleasure and not balanced by the required quantum of work would not be really lives of contentment and fulfilment.

I have referred just now to the need for men to have work to do, in addition to leisure. In fact those who have tried to analyse that intangible and elusive state of mind called happiness, have usually come to the conclusion that work which one likes is a necessary ingredient for achieving it. It may not be possible for all persons to have the type of work they would most like, but undoubtedly there must be provision for everyone to have employment which will enable him to earn the necessary income to buy the daily requirements of himself and his family. The problem of unemployment already looms before us menacingly; in the future it may acquire even larger proportions. It, therefore, behoves us to use all our knowledge and our scientific capability to take steps to deal with this problem and provide employment to the millions of our fellow-men before the problem gets out of hand.

In this country between 70 and 80% of the population lives directly or indirectly by agriculture. It appears that, unlike what has happened in many advanced countries where the farming community has dwindled to a very low figure, in India this is not likely to happen on a large scale in the next couple of decades at any rate. The problem therefore is one of finding employment especially for the members of the farming families. It would be tragic if there is a large-scale exodus from the countryside to the cities which are already over-crowded. The remedy seems to lie in a phased but rapid development of agro-industries, especially the small and medium ones, in the rural areas, taking care of course to see that problems of pollution, etc., are foreseen and avoided, and that the natural tranquillity and beauty of the countryside is preserved as much as possible. It is only industry which can give employment to very large numbers of people but it is not necessary that all industry must be located in the big cities. With the experience which is now available, and keeping in mind the agricultural transformation which has begun to take place, there seems to be a great opportunity for setting up a number of agro-industries specially selected for the needs of the various regions.

While I have referred so far to the many benefits resulting from science, there are also many undesirable effects from the wrong use of science. Everyone is now aware of the large-scale pollution of the atmosphere and the waters of our rivers and lakes which has come as the result of large-scale industrial enterprises, the increasing use of deadly chemicals as pesticides, etc. In everyday life also, one is made aware of how painful the devices which science has

given us can be. For instance we are subjected to so much noise—trains hurtle past, jet planes screech in the sky and transistor radios and loudspeakers violate the ether everywhere. Some people even seem to think that prayers cannot reach God unless they are rendered with the use of loudspeakers at full volume.

But if properly used, science is an invaluable tool not only for helping us to achieve greater agricultural production but also to help us to do our work with the minimum of drudgery; it can also give us many ways in which life can be made richer, fuller, more rewarding.

The Problems of Humanity

This earth of ours, at her fairest, is beautiful, wonderful. Witness the serenity of the deep cobalt-blue firmament on a fine day. And the shapes and forms of the ever-changing clouds—dazzling white cumulus clouds piled high, one upon another, or the fleecy, softly moving, cirrus types. What wonderful colours are displayed in a sunset: here, rose and amethyst melt into gold and orange, while there, mauve and lilac tints change and transform themselves into yet other indescribable hues, and the deep blue of the upper heaven softens into cerulean and lemon as it approaches the horizon.

Or, behold the spiritually uplifting world of the Himalayas; mountain range succeeds mountain range until the eternally snowclad sentinels of the north of our land are reached. Who has not felt elevated, far above the affairs of the mundane world, in this realm of snow-capped peaks, fair valleys and forests of whispering pines and deodars? Then there is the wonder of flowers whose colours held such a deep fascination for Professor Raman; the wonder of birds and butterflies, of rainbows, of palm-fringed golden beaches and starlit nights. And man himself has sometimes built marvellous temples and churches and mosques tapering into the sky as though trying to reach the realm of God, while in their interiors men and women have assembled to renew their faith. And finally, there is the miracle of human love.

But there is the other side of life. Nature can be terrible in some of her moods. There can be volcanic eruptions, earthquakes, floods, typhoons and cyclones, bringing death and destruction in their wake. We also know the term, "Nature red in tooth and claw". Animals and birds prey upon each other and when we look closely we find a terrific struggle going on everywhere. Man himself after so many centuries of so-called civilization is still engaged in bloody conflicts. Even after several world wars to eliminate war, there yet is no lasting peace. And in recent times, especially after World War II, so many destructive currents have been let loose. There appears to be a crisis of character. The traditional values are fast changing and one does not feel that man is making progress in all directions.

In music when man had reached such peaks as Beethoven's Ninth Symphony, why should now a stage have been reached when it could be said by some one that modern music covers a "multitude of dins"? Or, when visual art had flowered so magnificently in the work of the Old Masters and in the light-filled canvases of the Impressionists, why, again, should it have to come to a level where a cynic could comment: "the most consoling thing about modern art is that things can't be quite as bad as they are painted"? When many centuries ago, the

unknown sculptor of the time could create, in the brooding darkness of the Elephanta caves, the timeless awe-inspiring image of Shiva, and when at a somewhat later period, Michelangelo could carve the hauntingly beautiful Pietà, why have we come down in modern sculpture to twisted pieces of wood and metal, shapeless or grotesque masses of stone which sometimes are referred to, not by titles, but just by numbers? One recognizes, of course, that there are exceptions to what seems to be the general rule of decline, and dedicated, talented individuals exist.

As mentioned in an earlier paragraph there is a great deal of unrest in the world. An Indian newspaper recently quoted Pope Paul as complaining that the day's news consisted of "conflicts, wars, revolutions, upheavals, threatening tensions, power struggles and ideological struggles". It appears that generally there has been a great deal of disillusionment. When young, children are told of the wrong things which have been done in the past and they are led to believe mankind is now wiser and that there will be a better life for everybody. But when they grow up they find that the ideals which had been put before them are not being practised by the world at large. In the teaching in schools and colleges old beliefs, old conventions and time-honoured ways of living have been destroyed but nothing worth while has been given to replace them. Science has dealt a great blow to religion by showing that some of the postulates which have been handed down are untenable in the light of modern knowledge. And religions which have become encrusted with dogma and rituals have not reconciled themselves to the findings of science or made sufficient endeavour to prove their usefulness in modern life. From a comparative study, Trevor Ling comes to the conclusion that the great religions as they exist now are merely vestiges of what were once civilizations. They now consist of theological, ritual and possibly ethical elements only. He argues that each of the great religions was at one time "the expression of a new 'vision' of how human life needed to be organized in order to achieve a true spiritual orientation given a new emerging situation". He further says "Historical changes demand blue-prints for new civilizations, from time to time. Fortunate is the age in which prophets arise who can provide the vision that it needed". There is much in what he says and we are sorely in need of a new vision.

How do we ensure the right use of science? As we have seen, science can give us many, many things. But the pursuit of science should not be a dry academic or purely utilitarian undertaking. It should not lead to the state where someone had to declare:

"On the shore of intellect
I forgot how to fly."

Every discovery, according to David Sarneff, "reveals more clearly the divine design of nature, remarkable harmony in all things, from the infinitesimal to the infinite. Physical processes and laws imply a Supreme Intellect". How can we plan science teaching so that the student develops not only a mastery of the physical laws of nature but also a respect for and some understanding of the divine design in nature to which David Sarneff refers? How can we build up a race of people who, in the words of Tagore, would pray: "make my life simple and straight, like a flute of reed for thee to fill with music"?

In the earlier part of my address I have referred to the recent advances in agriculture and the hope and confidence which they have aroused that mankind can feed itself and also maintain a certain balance of nature if we think ahead and take the right decisions, including the laying down of a progressive economic policy. I have further indicated very briefly, and in the most sketchy terms, the role that science can play in augmenting our resources of food and materials, in finding how to restrain the growth of populations to manageable proportions and how science can give us the blessing of leisure in which to enjoy the fruits of progress. But I have also pointed out how in spite of astonishing discoveries in many fields—man has been able to walk on the moon four times during the very recent past—the greater part of humanity still suffers from lack of food, lack of clothing, lack of housing, lack of education and lack of medical facilities. Above all it seems to suffer from a diminution of the human spirit so that the spirit of contentment seems to be something that is vanishing more and more. What is it that we can do?

One of the great problems in building up and raising humanity to new heights is that while from time to time great leaders and great seers have arisen, there is no genetic mechanism for handing over their achievement to those human beings who follow them. Science has shown quite conclusively that normally acquired characteristics are not inherited. The experience of a life-time can thus be lost. There is a saying in an Eastern country that "experience is a comb which nature gives to man after he is bald." The problem is how to try and preserve the experience and the visions of a higher life which have been perceived by prophetic men. Another great problem is how to utilize the wonders of science so that they are applied for the uplift of man and not merely for material things. How can we prevent science being misused to spread death and destruction and pollution of the environment?

The answer to both of these seems to lie in the creation of a system of education which would, first of all, try to create conditions under which latent talent would be nurtured and developed. We do have some talent-search schemes for science, etc., but they tap a pitifully small section of our vast population. Studies conducted a few years ago, by a world authority on the subject, indicated that intelligence and the capacity to produce geniuses is not the monopoly of any one human race. But the well-being of a nation can well depend on the steps which it takes to discover those individuals who are gifted by nature but require the environment to bring out their special qualities. To take an example, India has done well in the world of sports in certain games like tennis and cricket. But what is the proportion of school children in our country who get a chance to handle tennis rackets or cricket bats and balls, leave alone receiving coaching from specialists? There must be many talented children who never receive the opportunity to show what they are capable of. The same applies to science and to other sectors. In a country like ours, there is tremendous scope for identifying at an early age and educating those who could contribute in a substantial way to the future prosperity of the country. The second and most important objective of the system of education must be to teach science in such a way that those who practise it are conscious of the beneficial directions in which they should try to

advance, and the harmful directions which should at all costs be avoided. In fact, such a system of education is needed not only for the scientists but for all others who are likely to be concerned with the use of the products of science whether it is for industry or for building up national defence systems, etc. While we cannot do without science, we can certainly try to see that education is re-structured to create a society in which the higher values of life will prevail.

This is a difficult task but not an impossible one because as Maurice Frydman has said, "The great achievements of mankind can be always traced to some great and simple intuition, some overwhelming inspiration, taking hold of one man's heart and mind till it becomes for him the most important thing in the world". Even a few devoted persons can in due course of time spread their message in such a way that the bread of life will be leavened.

How do we start doing this? How do we make a blue-print for a new educational system based on science? It seems to me that there is no alternative to assigning this task to a small group of very carefully selected individuals, not those who have hobby horses from which they refuse to dismount but those who are knowledgeable, who are filled with dedication to the cause of education and who are willing to give and receive in discussion. A large conference, in which in trying to reach agreed conclusions all is lost in the mediocrity of averages, will not serve the purpose. And once a really gifted group of individuals can lay down the guidelines, these should be considered at the highest level of government and implemented with utmost vigour and speed.

If we can do this and develop a race of mankind which will utilize the fruits of science while suppressing to the maximum extent possible the animal traits which we have inherited from our animal ancestry, there may yet be hope for *Homo sapiens*. Nature's gifts to the developing countries are natural resources, the most important among them being the human resources. At present human energy often lies idle and under-developed. To activate and develop resources in the developing countries, the need of proper education in all aspects of development is of utmost importance.

Finally, we should ponder upon what is our purpose in life on this earth of ours. Is it only to hunt for food, to reproduce the species, and to sleep? If that were so, man would be no higher in the scheme of things than animals, which also do the same things, sometimes with more grace than we. But if we consciously strive to use science and education to achieve life which is more imbued with the qualities of kindness and mercy, with vision, wisdom and energy, with more of truly human feeling and awe of the grand design of nature, we would be carrying out to some extent the high ideals laid before us by the Mahatma. We would also, by using science properly, pay our tribute to that great scientific spirit whose name the Institute where we are meeting bears.