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SCIENCE AT THE CROSSROADS

by

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PREFACE

That science in general, and particularly "chemistry and physiology are the two great magicians of the future, destined to open the eyes of mankind to the great physical truths" (to quote the words of a preceptor) forms the theme of this year's J. Srinivasan Memorial lecture arranged under the auspices of the Indian Institute of World Culture. As the subject has a topical interest to the general public, we have great pleasure in publishing this as our Transaction.

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Besides her academic distinction, Dr. Sharma has evinced keen interest in philosophical and cultural studies.

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FRIENDS,

As I ascend this rostrum my memory goes back nearly 25 years ago when my parents brought me here along with my two sisters, all clad in green nylon frock and “pavadai”, and I remember distinctly looking up at the venerable tall bearded figure addressing a crowded hall. The speech made no impact on me, but his kindly eyes and soft words to us after the meeting had ever remained as a benediction. And I feel grateful for the silent blessing of the Founder of this Institute, which has given me this distinctive privilege to address this august gathering today. The occasion, as you know, is the lecture in memory of the late J. Srinivasan, who was associated with the Founder B. P. Wadia on the administrative and financial side, and with the speaker a cousin, in blood and tongue, in hope and creed, both born in this glorious Bangalore, crowned by the fame of Sir M. Viswesvarayya and the eminence of Sir C. V. Raman.

The subject chosen is Science, which has assumed now such magnitude and importance and its contours are changed not only in degree but in kind as well, and the questions it poses are so complex and intriguing that one wonders whether they can be answered by invoking the spirits of Galileo, Darwin or Freud today. I am reminded here of H. P. Blavatsky’s statement that the Aquarian Age, ushered in 1897 marking the end of several cycles, will bring in great changes giving extra work for scientists and psychologists. Yes, to quote Shakespeare with slight changes:

> “Never was such a sudden mutation made
> Never cam? discoveries in a flood,
> With such a heady currance, scouring faults;
> Nor never Hydra-headed hypothesis
> So soon did lose his seat, and all at once
> As in this century.”

This change, or mutation if you like to call it, is evident in looking at the average person’s life. It was not much different between 3,000 years ago and 300 years ago; but if you compare the average man’s life in the seventeenth century and today, there is a big difference which is certainly caused by the impact of science. Another remarkable fact is that there are many more scientists working today than ever before. Ninety per cent of all the scientists who ever Jived since the beginning of mankind are living today, the number of chemists alone, my breed, exceeding a million. Of course, the immense world-wide activities of so many scientists are built on the recorded achievements of the past. More than three million scientific papers are published every year, of which the “Chemical Abstracts” alone cover half a million research contributions.

Having worked on both sides of the fence, I can refer to the two kinds of scientists: *(i)* the basic researcher, with curiosity as the impelling motive, reports his findings; and *(ti)* the applied scientist following the long road towards useful application of the discovery. Rapid advances are made through this programmatic applied research; as in the case of the first nuclear chain reaction from the discovery of nuclear fission taking only three years; and another three years from the nuclear chain reaction to the nuclear explosion.

Cornucopia:

An extraordinary tool is now in the hands for use in science by the discovery of atomic energy with its radioactivity and isotopes. Apart from the evil effects of atomic bombs, endangering the security of the world, of which only is the public aware, there is the production of electrical power out of this energy which is a vital contribution to the

civilization of the future. Another breakthrough is in the field of genetics with the deciphering of the DNA code which gives us an insight into evolution and life itself. Many more developments of vital importance can be detailed, but suffice to mention only a few of them: New apparatus for making measurements have been devised by the perfection of electronic equipment, which has accelerated laboratory readings and experiments. Mathematical computing machines have revolutionized many branches of science, making possible the solution of hitherto insoluble problems by carrying out with accuracy in minutes calculations that used to take months. Advance in communication has shrunk the world. Isolated islands of prosperity in a sea of poverty are no longer acceptable. Fertilizers, pesticides and applications of genetics have revolutionized agriculture, making possible a surplus of food as in the United States today. Spectacular medical advances with antibiotics and new surgical techniques have virtually eliminated such diseases as malaria, yellow fever, typhoid, tuberculosis and poliomyelitis.

There is a high level of standards in comfortable living, say, by pushing a button in any room, you get the work equivalent of ten men at a cheap price of 10 paise an hour. You have only to compare the air-conditioning system today with the Red Fort cooling methods in the Moghul days. The abundance of material goods in the form of food, clothing shelter, transport, health, comfort, protection and entertainment are a measure of the wealth of the community — all due to the development of science and technology. Aye, here is the rub: all this floodtide has promoted the rich to become richer and the poor poorer, whether as individuals or collectively as a nation. The way science and technology have been used or abused the world over has only led to increased social injustice, the depletion of natural resources, degradation of environment — in short, the three P's: poverty, pollution and population. Does anyone concern himself genuinely for the thousand million poor all over the world, living in villages without the benefits of the cornucopia which science has brought to the few? (Yes, there is the fourth P — the politician to exploit them.)

When people are living at a subsistence level, all their time and energy are devoted to getting food and the bare necessities, with no time to think of new ways of doing things. It is only when they go beyond the subsistence level, they can have machines to do the work of many men, thus creating more wealth to get bigger and bigger machines. With the release from drudgery come arts and crafts, science and research and newer technologies.

Historians have noticed that in almost every age there is an outburst of creative activity; for gifted minds have taken a special interest either in architecture in one century, and to painting or music in others. This century dawned with a tremendous transformation of the scientific view of Nature, which could only be compared with the change of outlook brought about by Copernicus. Every student of science knows that Gottingen was the real centre of the restless intellectual activities of the physicists in the early twenties to which many American scientists came with J. Robert Oppenheimer, usually called the "father of the atom bomb" leading. These Americans were styled "Knights of Columbus in reverse", as they were in search of a "new continent". But the honeymoon lasted in Gottingen only for a decade or so, before Hitler's anti-Semitism drove them out; and only the United States with its hundreds of universities and institutes could provide enough places for the scientific refugees. Albert Einstein's appointment at the newly established Institute for Advanced Study in Princeton was hailed by the *cogniscenti* as important an event as the transfer of the Vatican from Rome to the New World. "The Pope of Physics has moved and the United States will now become the centre of the natural sciences."

Does change imply progress?

And what a strange paradox of history that the German nuclear physicists, living under a dictatorship, had a better conscience for human welfare and prevented the construction of an atom bomb than their colleagues under democracies who had no qualms whatsoever in producing the deadly weapon! and what is more, dropping it over the heads of the innocent millions! A perusal of Robert Jungk's classic "Brighter Than a Thousand Suns", which gives a personal history of the atomic scientists, nearly 25 years old, proves the age-old maxim that the way to hell is paved with good intentions, for as he remarks:

> "Thus the sum of a thousand individual acts of an intensely conscientious character led eventually to an act of collective abandonment of conscience, horrifying in its magnitude."

And shall we recall nearer home, albeit on a smaller scale, our nonviolent freedom struggle leading to the holocaust of partition and its aftermath?

But let me not digress into the question of value judgments, for the role of science in cultural evolution is clearly an ambiguous one. What did T. S. Eliot mean when he observed in ''Burnt Norton":

"Human kind cannot bear wry much reality" ?

Science, it is obvious, is an instrument of change and a scientifically based culture is devoted to the dynamics of change. But does change imply progress? And are we to use the concept of progress only within a human context and with whatever value judgment we wish to place arbitrarily upon it, or can it be employed within a broader evolutionary context where change and chance are the rule and predetermined goals are non-existent? The theory of progress as applied to man is purely a human conception. It arose during the period of Enlightenment and reinforced by the emerging industrial revolution. To understand this issue better, let us look at any metropolitan city, Bombay or New York in the last century and today. Taking any aspect of progress, say, transport: the automobile may be a progressive development from the horse and the jutka*; but* it raises the question whether progress of this type has truly improved the quality of life for man or has it contributed to more pollution and accidents ? When does progress lose its value ? Maybe, progress is not a linear straight line but a spiral with rhythms of advance and retrogression.

The New Clergy:

Leaving culture and progress from the domain of science, let us enquire what the role of science is in society. Just as there was no appeal from the power of the Church without risking damnation in mediaeval times, so now there is no appeal from the power of science without risking a charge of irrationality or insanity. We may no longer respect the ecclesiastical robes, but the doctoral robes of Harvard command deference and attention. With the Bundys, Galbraiths and Kissingers, the Harvard has become the modern Canterbury. From small beginnings, science has expanded until it is now world-wide in scope and influence. It now constitutes the new clergy, as numerous and better paid and more powerful. That modern science has transformed and to a large extent determines modern life is a point too well known to be labored. No aspect of life today can remain out of the pale of science, when by science is meant not only physics or the physical sciences, but the whole range of empirical enquiry which can be conducted on an experimental basis and in a controlled way including history, archaeology, philology as also the whole spectrum of the so-called science of Man. The ubiquity of science, both pure and applied, is that from any perspective and in defense of any interest, it cannot be ignored.

It is interesting to see the differing views of science from two world leaders. Pandit Nehru addressing Parliament in 1958 said:

> "Science has given to the common man in countries advanced in science a standard of living and social and cultural amenities which were once confined to a very small privileged minority of the population."

But Adlai Stevenson addressing a meeting of the International Astronomical Union two years later observed:

> "You (scientists) have given us dangerous powers, but we have not yet learned to control them. You have given us the tools to abolish poverty, but we have not yet mastered them. You may have given us the means to extend the span of life, but this may prove a curse, not a blessing, unless we can assure food, survival and then good health and a good life for the bodies and minds of our exploding populations. You may have made the world small and interdependent, but we have not made the institutions to manage it — nor cast off the old institutions which scientific progress has made obsolete. . . We are ever running to catch up tomorrow with what you made necessary yesterday."

It is obvious, therefore, that while science can solve many problems of the human race theoretically, man has failed to implement them practically. The solving of human problems lags far behind the solving of material problems. This means that in an atomic war, which involves no time, the human race has the physical power to commit suicide and turn over the habitation of this planet to the cockroaches and the insects which can survive then better than man in a radioactive atmosphere.

Thus science is put on the pillory and scientists stand in the aura of tragedy like Shakespearean heroes. The Hamlet of today would not be a prince but a nuclear scientist, as is evidenced by the soliloquy of a Central European scientist in Los Alamos, the atomic city, in 1949:

> "What an extraordinary and incomprehensible thing! My whole youth was absolutely devoted to truth, freedom and peace; and yet fate has seen fit to deposit me here where my freedom of movement is limited; the truth that I am trying to discover is locked behind massive gates; and the ultimate aim of my work has to be the construction of the most hideous weapons of war. Could fate have been more perverse ?"

Scientific Estate:

But let us turn away from such a pessimistic view of science; for to speak of it in terms of the atomic bomb would be like thinking of electricity in terms of the electric chair. Let it not be forgotten that the scientific estate (to speak in terms of the subject of last year's Memorial lecture) is the first of the four professional estates of the modem age, the other three being technological (i.e. applied skill), administrative and cultural (artistic and religious) — all the four being based on Knowledge. It has to be borne in mind that the ethos of this scientific estate is the monad that contains within itself the image of the future society.

But for our atomic scientists, man could not have landed on the moon. It is more than a decade since the ultimate in impossibility expressed in the phrase: "You might as well wish for the Moon" has been accomplished; for not only has he landed on it, but he *holds* it in his hand, weighs it and analyses it. In the last decade more knowledge about the moon has been garnered than in all the centuries, when we have been indulging in romantic illusions and fanciful theories. Although it took less than a decade to build the Apollo to go to the Moon, it takes longer to understand all that was found there. The materials gathered there not only

tells us about that satellite but much more about our own planet and the Sun.

The great scientific revolution of the sixteenth and seventeenth centuries, spurred on by the work of Copernicus, Brahe, Kepler, Galileo and Newton had firmly established the basic nature and mechanics of the solar system. But it was not before the dawn of this century were the scientists in possession of the tools and insights to unravel the continuous changes going on in the earth, since its formation four and a half billion years ago. The first quarter of the earth's history was missing till we are able to build it from the facts revealed by the Moon, as the rocks of the earliest times have been eroded from the face of the earth. But in July 1969, the study of the moon soil has given clues to the missing record of the earth's childhood. Instruments left behind are even today continuing to send back to earth more data on vibrations, heat and magnetic field of the moon.

The moon was evidently formed at the same time as the earth and the rest of the solar system; and chemically it is similar to the earth. But there are differences which make it hard to argue that the moon and the earth were ever part of the same body. The moon's early history was marked by great primordial heating, caused by catastrophic bombardment by huge asteroids and of great outpourings of molten lava, followed by three billion years of comparative quietude allied to death. The moon is "dead" not only biologically but romantically too.

Solar System:

As a by-product of the exploration of the moon, man has learnt the technique to probe the rest of the solar system. There is no air or atmosphere in space in the moon; but there is a "wind" which is made of streams of single atoms that have been blasted out of the sun's incredibly hot atmosphere and shot into space at speeds of several hundred kilometers per second. This stream of atomic particles, called the "solar wind", is a sample of the matter that makes up the sun. And our astronauts have brought us not only a sample of the moon but of the sun as well.

AU life on earth is dependent on the sun and yet we know very little about it. It is only in the twenties that we came to know that the sun is a giant nuclear reactor, consuming its hydrogen atoms to form helium and releasing energy at a rate equal to the explosion of a billion hydrogen bombs every second. The sun too, like a human being, has a life history: born billion years ago in the hot centre of a collapsing dust cloud that formed the solar system, the sun is now in a steady, quiet middle age. In a few more billion years, it will grow old and die, per hap, by cooling or in a sudden explosion. Remember, what the " *Voice of the Silence*" says *in* this regard:

> "Behold Migmar, as in his crimson veils his 'Eye' sweeps over slumbering Earth. Behold the fiery aura of the 'Hand' of Lhagpa extended in protecting love over the heads of his ascetics. Beth are now servants to Nyima, left in his absence silent watchers in the night. Yet both in Kalpas past were bright Nyimas, and may in future 'Days' again become two Suns."

The moon may have no life; but even its sterilized soil contains traces of the chemicals out of which life can be built. The basic ingredients for life are common: a little bit of sun, a few ordinary atoms, and some interstellar dust. These, put in a protective incubator like the earth, change from simple molecules into complex structures, and cross that border line separating chemical molecules from living organisms. These conditions must have been achieved, thousands or even millions of times in incubators like the earth, which must be scattered among our own modest Milky Way galaxy containing hundred billion stars, of which our sun is a most insignificant spark. If 1945 was a shameful year in the world's

history for dropping the atom bomb, 1969 was a memorable year for landing on the moon — both being offspring's of Science: Cain and Abel. The moon is no longer just our satellite, but a base, a way station on our long road to continuing scientific exploration into the vast spaces of the universe.

But scientific investigations are not confined only to the cosmic, infinite, celestial spheres but goes deeper into the minutest atomic structures too, in the graphic Upanishadic phrase:

"Anoraniyan Marathi mahiyan."

The most esoteric part of this enquiry is related to particle or high energy physics: a realm of the entities fleetingly observed in cloud chambers, when the nuclei are torn apart by high energy missiles such as neutrons, protons, etc. They can be tackled only in a complicated language that few speak and understand.

Life Principle:

We know as little about these very small particles as about the very largest which are less amenable to our experimentation. The decades of the sixties presented astronomers with quassars, pilsars, X-ray stars and radio emissions, revealing not only hydrogen atoms but hydroxyl and cyanide radicals and other molecules in inter-steller space. The discovery of small organic radicals and molecules in space increases the plausibility of the mechanization for chemical evolution on earth.

The controversy about spontaneous generation lasted for several centuries till Louis Pasteur demonstrated conclusively in the last century that micro-organisms could not arise spontaneously. It has been proved that Pasteur did not discover bacteria, but only discussed the nature of their activities, as it was discovered even earlier in 1683. It is interesting to note in a letter to the *New York Times* that a Latin poet Terentius Varro (39 B.C.) was referring to the famous Atacinus speaking of bacilli in these words:

> "Small creatures, invisible to the eye, fill the atmosphere in marshy localities, and penetrating with the air breathed through the nose and mouth into the human organism, cause thereby dangerous diseases."

The above quotation is referred to by Blavatsky in her *Lucifer* for April 1891.

Biologists have been for long debating whether life is vitalistic or mechanistic and the thrust of molecular biology is giving support to the latter, as it proves that the cell is essentially a chemical factory in which small molecules are changed into large ones, the energy for the synthesis coming from the stored materials. They have also shown that heredity and the mechanisms of growth and development follow and obey the laws of physics and chemistry. As Mrs. C. Jacker points out, there are several new specialties such as biophysics and bio-electricity, which demonstrate that the nerves and muscles operate in accord with physical laws, and that thought and memory can be reduced and explained by neurologists and psychologists as simple electrical and chemical processes.

At the Crossroads:

Modern science is now specializing in crossroads area, where the knowledge of several specialties is necessary for any progress to be made. Is it not obvious that without a knowledge of physics and chemistry, it is impossible to make any research into the functioning of the brain ? Similarly have electronic engineers found that the parallel between

machine operation and that of the brain is too close to be ignored. Hence in recent times, the synthesizing subjects such as bio-engineering, bio-physics and bio-chemistry have been developed. Two such fields that are playing a significant role in the biological revolution are bionics and cybernetics, which deal with control and communication in animals and machines.

There is a section of opinion which looks on such artificial intelligence machines as being malevolent, as Frankenstein monsters, as if machines and humans are inherently enemies of each other. As well call the car as being more malevolent that the bullock cart! Humanity has now an opportune chance to learn about itself and the universe, standing at the crossroads of the sciences. Bionics and cybernatics reveal more and more to us about the functioning of the brain; and neurology and molecular biology, united with physics and engineering, have opened up new possibilities of a productive union between man and machine that would inaugurate the Third Industrial Revolution. For in the last three decades a number of startling advances and breakthroughs in almost every branch of science has begun to make several dents in our social, political and economic life.

But a note of warning is essential. While the value of science and the scientific method of thinking as critic of superstitious and dogmatic beliefs is beyond dispute, the tough-minded rejection of all forms of ideas which do not submit to the procedures of the scientific method, as now conceived, is as much of an abuse of intellectual powers as the exploitation by religious fanatics. Readers of MANAS would have noted the charting of a middle path for scientific thinkers which does not shut off intellectual daring and adventures of the mind, and at the same time providing necessary protection against fashionable extravagances. Michael Polanyi, a scientist of some distinction who can hardly be accused of being "anti-scientific," in his book "*Personal Knowledge*" endeavouring to restore science to its proper place among the Humanities, shows that it is *one* way of using the mind, but not the *only* way. When doubting or rejecting all that cannot be made demonstrable becomes a general theory of knowledge, science becomes self-destructive.

Responsibility:

There are so many voices heard today about the role of scientists in this mad world that there is hardly any clarity concerning what scientists *ought* to do, although there is already a great deal of evidence that *something* needs to be done. Turning to religious belief will not help, and hence scientists are the ones to whom the public appeals thus: "Look at the modern world, see its pain, feel the longing, the fear and the hope of the people, and try to determine, using all your talent, all your problem-solving experience, what might be done to lighten and relieve the present human condition. Nobody is asking the scientists to *do* anything except accept more responsibility for the impact of their accomplishments, and the misapplications of their thinking. They need either to redefine science or become much more 13

than scientists." This is yet another crossroad on which science stands today.

The history of science tells us that people who rely on the argument of Descartes, the archetypal player of the doubting game, insisting on clear and distinct conclusions, *do* get the wrong answers along with the looked-for right ones. Did not the eighteenth century scientific sceptics make serious mistakes by insisting on *their* kind of explanations or theories? Did not the French Academy of Sciences deny the fall of meteorites, simply ignoring the abundant evidence for them, because of the supernaturalism of popular explanation? It was again scientific scepticism which brushed aside all the instances of hypnotic phenomena occurring in the form of miraculous cures and spell-binding. Are there not other doubts, which we now

sustain as reasonable on the grounds of our own scientific view of the world?

Facts and Delusions:

Some of these doubts may turn out one day to have been as capricious, prejudiced and dogmatic as those from which we have now got out. Where will the habit of ignoring possibilities which seem unverifiable today lead us? Will it not open the back door to unexamined and unnoticed assumptions which will be all the more polluting? An instance of this danger in the field of medicine is given by Walsh McDermatt in a recent issue of *Daedalus:*

> "At any one time the body of knowledge that forms the practice, especially the therapeutic practice, of medicine is a curious mixture of a highly effective technology interspersed with islands of dogma, empiricism, conventional wisdom, and at times, superstition. With the exponential growth of 'interventions', however, this situation can no longer be tolerated. The persistence of invalidated technologies leads not only to serious diagnostic error but to waste of skilled services and of money; it also contributes to the increasing load of medically induced, i.e. iatrogenic disease and, by perpetuating untruths about serious chronic diseases, can give rise to untold anguish and misery."

What Dr. McDermatt and Ivan Illich in "Medical Nemesis" and other writers are urging is neither anti-science nor an angry outburst against medicine but a simple exposition of what people should know about the human condition and what may happen to make it worse when delusions of certainty are allowed to rule the decisions of trained specialists. Dr. Lewis Thomas, whose major contributions to a Boston medical journal are collected and published as *"Lives of A Cell* is another model of self-examination, especially for doctors of medicine. If they look about, scientists will always be able to find, among their own number, examples of people who are doing precisely what needs to be done.

When scientists themselves are at such cross purposes, the lay public is at a loss to find his bearings. Whereas in earlier times, the critics were only questioning the adequacy of science and stressing its limitations, today the reliability of science as a source of knowledge is itself questioned. C. P. Snow's "Two *Cultures*" fostered the misconception that in the twentieth century the humanities have been the province of unqualified hostility to science. After Hiroshima and Vietnam, there was an alienation by a large segment of people from science and science-based activities and by the late sixties, many were prepared to accept the neo-romantic critique of science at the core of dissident counter-culture. Theodore Raszack's two books "The Making of a Counter- Culture" and "Where the Waste Land Ends'' comprise the most systematic effort to formulate a reasoned, coherent ideology expressive of the diffuse antagonism toward science, technology and scientific rationalization. In one sense, this attack on rationality is to be interpreted as an extreme expression of a current mood. It is also a new phase of the "romantic reaction" which started nearly two centuries ago when, as now, the reliability of scientific knowledge within its own proper sphere was not in question. "They did not," to quote Emerson, "doubt the absolute validity of natural facts", but urged with a view to satisfy the full range of human needs, the importance of 'marrying' the natural data to value-laden concepts arrived at by other intuitive, mytho-poeic, holistic way of knowing.

Tammany Hall:

This is an era of public participation in science. The once widespread belief that scientists alone should have domain over the scientific enterprise is being replaced by a philosophy that calls for public involvement in *science. In* important ways the public

influence brings in the Tammany Hall *of* politics in the sphere of Science affecting the course of research itself. What a contrast to the idyllic atmosphere of peace and isolation in which the most far-reaching revolution in science was born in the twenties of this century: with the scientists from all countries striding in the picturesque park in Copenhagen, in a quiet street in Berne, on the shore of the island of Heligoland, in the meadows and tree-shaded river at Cambridge, in the Hofgarten in Munich, the quiet neighbourhood of the Pantheon in Paris, the gentle slopes of Zurichberg and the ancient fortifications of Gottingen — all reminiscent of the Peripatetic's of the Periclean age!

Certainly the advent of public participation has changed the social climate in which the scientific community works today. Are we aware of the great public debate going on the question whether research can go on recombinant DNA for the last four years, and where the Mayor of Cambridge has banned that research in Harvard MIT? This controversy is reminiscent of the dispute between the Church and the State in mediaeval times. The old image of science as the endless frontier is giving way in some quarters to the notion of science as a suspected frontier. More details of this debate are to be found in a recent issue of *Daedalus* devoted to the subject of "Limits of Scientific Enquiry". This is in consonance with the trends of the times when we are imposing limits in every sphere of activity: speed limits, limits to natural resources, and energy supplies, limits to the elasticity to which environment will respond to man's marauding adventures, limits to food supplies, to population, to exercise of power and limits of growth. We are fast moving from the era of frontiers awaiting to be exploited to the era of a limited globe condensed to a crowded life-boat.

The Moon landing has given visible significance to the idea of "Spaceship earth". Even as scientists continue to explore space, "the vast heavens above", in Pascal's words, they have to turn within, to "the mind of man below". They have to turn their skills back toward our earth in order t3 learn how it operates and how man can continue to survive on it. The ancient, sterile desert of the moon is a grim reminder of the fact how narrow is the line between life on earth and the lifelessness of our surroundings.

Leap into Cosmos:

Yet another fact revealed is the truth that nothing great can be achieved without human co-operation. In earlier times, poverty-stricken scientists were carrying on their experiments in ivory tower isolation. But today the combined resources of government, scientists and technological equipment have brought forth a most impressive human achievement, dwarfing the pyramids and cathedrals of old. The scientific resources of 120 universities and technical abilities of 20,000 American firms have gone into the recent NASA experiments. Half a million people were employed and several more millions were provided work in the experimental stations. The Apollo/Satum spacecraft was over 100 meters tall, weighed over 2| million kilograms and contained 15 million separate parts. But its cost was less than one-fifth of what the Americans were spending on cigarettes and liquor alone. Ten years of planning and spade work came to their climax in a few months in 1969.

Marie Curie initiated the leap into the cosmos at the dawn of the Aquarian age by the discovery of radium and ever since the shape of science has changed with the great develop-ments ushered in by such names as Planck, Einstein, Rutherford, Bohr, Sommerfield, Franck, Schrodinger, Heisenberg, Born, Fermi, Pauli, Dirac, et al. Along with the new scientific concepts, religious ideas too are undergoing a new mutation. Genetics for long was a form of Calvinism, as there is a sort of predestination at the time of conception. What

genes an individual has is determined by what sperm unites with what egg. The genes of the gametes become the genes of the zygote; and, by repeated equatorial division, of all the cells of the adult body. But in the formation of the next generation of gametes, chance enters in during the reduction division, in the assortment of the various alternative alleles, but the distribution must always be made from the genes available in the individual as a result of the earlier fertilization. Chance operating within predestined boundaries determines the possibilities of the succeeding generation.

Genetic Engineering:

The deciphering of the genetic code has now made it possible to change at will the chromosomes which determine the development of the species. Our knowledge of the mechanism of propagation has grown dangerously fast with the investigation into the genetic material of the chromosomes which is in the form of very long thin molecules of deoxyribonucleic acid, called popularly DNA; and human interference with the hereditary structure of germ cells is not completely out of sight. Man has already created new races of animals by cross-breeding and purposeful selection; and the same has been done in plants. The natural evolution of the animal world has been tampered with by human interference. Will man be far behind from this interference? Is it that Nature unaided fails or is it that Nature aided faces a Frankenstein? Will it not be the Second Fall of Man when the new evolution sets in? No longer dependent on cosmic rays to produce mutations and new forms and ways of life, Man is on the threshold to take upon himself to develop Nature and his own species.

Science fiction has created frightful fantasies about genetic engineering, but if we do not allow our imaginations to run wild, we can sanely look at the new approaches that will be available to mankind in the near future, almost certainly in the next century. They include the control of sex of offspring, the use of sperm banks to provide for fertilization of eggs in special cases, the transplantation of organs from one person to another (already possible from the mid-fifties), the implantation of fertilized eggs into a foster mother (the test tube baby is already arrived), the modification of prenatal and postnatal development to provide for “better” individuals, the production of new individuals with the same genetic composition as that of a presently existing one (cloning), and the manipulation of the genetic material either to repair defective organs or to improve the performance of presently existing ones.

But religious and ethical beliefs conflict with the proposed procedures and a great controversy is raging in the press and the pulpit. The tragedy is that our technological, scientific and informational sophistication has far outstripped our social management of these forces. Here one is reminded of the classic *Moby Dick,* where the white whale was the symbol of all of the powers that lay beyond man and that might curtail his activities in any way. Captain Ahab drove himself, his crew and his ship to destruction in his effort to destroy the whale. As the climax approaches, the driven Ahab confessed with illuminating insight that while all his means were sane, his motives and objects were vitiated.

Further Evolution:

If the new physics and chemistry gave man the ability to reshape the world, the new biology has given him the opportunity to reshape himself. The possibilities of the physical revolution, both good and bad, were not anticipated when the atom was split; likewise with the possibilities of the biological revolution. But let us realize that conditions are created which make it impossible to put the clock back for any return to the *status quo*. Man must move forward and impasses are to be overcome by further evolution.

It is fascinating to speculate that the dangers we are facing today in *terms* of nuclear pollution, poverty or population are not much different from the primordial danger facing the earth at the appearance of oxygen in the atmosphere, when life had not appeared and the atmosphere was like that of the moon free from oxygen. Very probably, it was this lack of oxygen which made possible the formation of the first complex organic molecular combinations, for its presence would have caused their quick decay by oxidation and prevented the slow accumulation of organic molecules. It has to be remembered that plant life began with the evolution of molecular structures capable of transforming sunlight into chemical energy. This was inevitably connected with oxygen production. Here nature had run into an impasse, as oxygen was a pollution then. But the transformation of sunlight into chemical energy was a very useful development, as it helped living creatures to withstand the rigours of life: while the inevitable production of oxygen must have been harmful to the molecular structures, causing their decay. Plant life had started by “polluting” the air with oxygen. But further evolution improved living creatures sufficiently so that they could resist the oxygen “pollution", and also new species were created whose whole existence was based on the presence of oxygen. The evolution of the animal world and eventually of mankind would have been impossible, were it not for the initial atmospheric pollution by oxygen!

The scientific and technological progress has put us in a sudden outburst (referred to in Shakespeare’s lines at the beginning of this lecture) of a new variation in our tradition. The question naturally arises: “Will the pollution of today become a boon of tomorrow and the blessings of today cause the pollution of tomorrow?'

The Next Step:

If we look at the problem in a philosophic way, which is not much different from the scientific way, a doubt arises whether human beings are not producing a false sense of self out of a series of intense particularizations of will, thought and feeling — all of which are the tokens of selfhood. In such a state, the mental environment seems far more important than the external physical environment. Then, one is able to recognize that there is no separation between oneself and the world except in language, customs, habits and assumptions. Most importantly, there is no separation between oneself and other human beings as centers of consciousness. The notions of *meum* and *tuum*, attached to pleasure and pain, to joy and suffering, are arbitrary and false. Suffering is intrinsic to the universal stream of conditioned existence. Most living is a kind of pseudo-participation in what seem to be vents, but are merely arbitrary constructions of space-time, and are largely non-events. When one comes to see that involvement of a single universal consciousness in a single homogeneous material medium, the very notion of the individual “I” has dissolved. If the ego is recognized as a form of blindness and mankind as a single interpenetrating field, then Dante’s:

*“ L'amor che muove it sole e l’altre stelle"**

is more than a metaphor. In such an event, the next step in human evolution cannot be simply the growth of another organ or the shedding of one as the tail, nor even the development of another tool added to a list that stretches from the fist-hatchet to the computer, but a transformation that altered an ape into a man: a mutation that we have been waiting for.

Such a mutation can take place only when we reshape the world with the power we have at our command, not like Caliban but as Prospero. It may not be an easy task, but the ancient Hebrew tradition comes to mind: we will struggle in the dark like Jacob contending with the angel all night long until daybreak and exclaim:

“I will not let thee go except thou bless me.”

And the blessing will come when the relations between scientists remain beyond the tensions and conflicts of the day and the world community of scientists are joined together undivided as an international bridge between divided parts of mankind and as a spearhead towards a better world.