Sources of Man's Knowledge*

Vikram A Sarabhai

I was reading the other day an account of some famous Spanish Captains, who, many centuries ago, undertook daring voyages of exploration in unchartered oceans far from home. The explorers had to persuade their King to provide good ships with men and stores. They presented prospects based partly on the fragmentary observations of earlier explorers, but largely on imaginative dreams. Craving for knowledge, a romantic love for nature and adventure, lust for wealth and power, courage of a rare type – these were the ingredients which pushed forward man's exploration of the earth. Today the scene differs only in detail, in dress, and certainly in the number of copies in which project proposals have to be submitted to sponsors!

What urges man to explore space, the vast and seemingly boundless region which extends beyond 20 to 30 kilometres from the surface of the earth? In answering this question, it is useful to identify four regions of space. We have firstly the earth bound space which constitutes our immediate environment encapsulating a small domain in the solar system. It comprises the region in which the influence of the earth's magnetic field extends, and since the upper atmosphere largely consists of charged atoms, molecules and electrons which are affected by the magnetic field, the material environment is also quite distinctive in this region. Beyond it we have the second region which is interplanetary space bound to the sun. This is largely dominated by an extremely rarified and continually expanding gas from the outer corona of our sun. Such rarified gas, in this case composed of charged particles, mostly electrons and protons, is called 'plasma'. Earth bound space is contained in plasma flowing from the sun, a 'solar wind' as it is called. This provides a new medium to carry solar influences to the earth and to the other planets. Largely on account of this wind, the tails of comets always point away from the sun. For the same reason, the earth's magnetic field is blown out in the form of a tail.

* National Programme of Talks, Series: 'Exploration in Space', 1966. Courtesy: ISRO, Bangalore.

Beyond the solar system at a distance from the sun about 40 to 50 times that separating the sun and the earth, we have interstellar space in our galaxy, which is our third region. Here too we have a very rarified medium of neutral and charged constituents of matter in space separating the stars. Astronomers talk of yet another space beyond our galaxy where there are countless other galaxies and strange bodies. Extra-galactic space is the fourth region.

Many people suppose that there is the absence of the imaginative and intuitive element in the pursuit of science in contrast to philosophical, literary or artistic endeavour. This surely is a fallacy. What distinguishes the scientist is his compelling urge to test his concepts in terms of observations. He is ready to let his castle crumble to dust on the results of experiments. As long as man was tied to the solid earth, all he could observe of the outside environment was through information gathered from radiations which could penetrate the atmosphere and the magnetic field of the earth. He had access to only a few windows in the vast spectrum of electromagnetic radiations. Optical and radio astronomy provided the base for our early concepts of the solar system and of the Universe. He had moreover information derived from low energy charged particles which could approach the earth near the Poles and formed beautiful auroral displays. He could also study the more energetic cosmic rays created in the galaxy through as yet imperfectly understood mechanisms, and sometimes those coming from the sun. From all these a complex edifice was built of theories of cosmology, of galactic and stellar structure, of matter and fields in interstellar and interplanetary space and much closer to us, of the configuration of the earth's magnetic field and of phenomenon in the earth's atmosphere. Research with rockets which make excursions into space, or with satellites which remain in orbit around bodies such as the earth, the moon or the sun, free us from the severe constraints imposed on our ability to make direct observation relevant to these theories. New results of the last few years have already confirmed several theories and concepts derived earlier. They have also demolished many others.

Some of the fundamental problems which concern scientists today are no different from those that have excited man's curiosity from earliest times. We would like to understand the creation of the Universe, the solar system, the stars and the planets, the origin of life itself and the seemingly mysterious influences through which the sun affects the course of human existence on earth. Space research is related to all these.

As technology progresses providing new capabilities for space exploration, it is possible to reach out from observations in earth bound space to the moon and the planets in interplanetary space. The studies of the solar wind in which the earth swims, and of the particles and fields carried with it probably acting as trigger for many occurrences on the earth, are some of the immediate objectives of space research. Another, which concerns the study of planets is of interest to geophysicists as well as to biologists. The earth has a molten core with a magnetic field and a wide range of chemical elements and compounds in its interior and in the atmosphere. These environmental factors along with those related to the mass of the planet and its distance from the sun which controls its temperature are presumably related to the existence of life on earth. But one of the most truly remarkable aspects of life as we know it is that its basic building block, whether in a blade of grass or in a microbe or in man or in giraffe, in all cases is the wonderful substance called 'DNA'. This type of life can survive only within a certain range of environmental conditions. We would like to know whether other planets have environmental conditions, which could permit life based on the DNA molecule. Or is it possible to have other forms of life, which are based not on carbon, hydrogen, oxygen and nitrogen, but other combinations of elements including iron, as is conceivable in Mars. At this stage we run into speculations, but scientists will not rest till they confirm these through observations. It may well be that there is no other planet in our solar system which can sustain life, but then there are hundreds of millions of stars like our sun which can have their own planetary systems. At the present time many implicitly carry a conviction that life is unique on earth. If and when this proves to be wrong, I would like to suggest that a very fundamental transformation will occur in the way man looks at life and nature.

There is an active debate in the world today on the value of space exploration in the context of the many immediate problems of human existence. Why does man wish to go to the moon when he has sophisticated instruments including television cameras, which can be sent in spacecraft under command and can communicate information from millions of miles. It is because nothing that has been developed with the most sophisticated technology so far approaches anywhere near the capability of man who possesses the facility of receiving information simultaneously from a number of channels and to synthesise it to create an image of the environment as a whole. Let us note here that our present day computers and systems for analysis operate only serially i.e., taking one bit of information after another. It is unlikely

that man will restrain his image to see, to feel and to listen, himself if he can possibly accomplish all these. I do not expect that the debate on the merit or otherwise of putting man into space would ever be settled. If we are to rely on historical experience, man will surely push ahead with adventures of this type backed by motives which will inevitably be mixed.

In India the immediate goals of our space research are modest. We do not expect to send a man to the moon or put elephants, white, pink or black, into orbit round the earth. Our objective is to understand primarily the region of the atmosphere from forty to about two hundred kilometres above the surface where balloons will not reach and satellites cannot operate for any length of time because of the drag of the atmosphere. This region of the atmosphere which is studied with sounding rockets is crucial to understanding the processes by which solar influences ultimately penetrate to the lower atmosphere where weather changes occur. Aeronomy is a word which was coined not so long ago to describe the sciences including meteorology related to the earth bound space. Study of aeronomy is of great practical application, particularly to a country, such as India, where much of the gross national product is dependent on rain fed agriculture.

Special consideration is now being given to the peaceful uses of outer space of particular significance to developing countries. A most exciting prospect within our reach in the next few years is the establishment of what is known as a synchronous satellite over the Indian Ocean. It would keep constantly under observation the vast area of the Indian Ocean which has as yet very few observing points from which we can derive information of great importance to meteorology and long range weather forecasting. An equally exciting development is a synchronous direct broadcast television satellite which would make available a most powerful means of mass communication to reach about two thousand million people in an economically depressed region of the world. Physical and financial inputs are of course necessary for their economic and social uplift, but surely an essential ingredient of our success is the ability to communicate with the widely dispersed population in the region for improving agricultural productivity and permitting programmes of population control. Space research also confers an invaluable, though intangible, advantage through the spread of advanced technologies which are related to economic development and security. These technologies should materially assist developing countries, such as India to leap-frog from their present status.