

UNITY BENEATH DIVERSITY : THE MESSAGE OF SCIENCE

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It is a fitting tribute to the great achievements of Sir C.V. Raman that we have chosen the anniversary of the announcement of Raman Effect as the National Science Day. As a scientist, I am happy that such a celebration of Science Day is also a recognition of our awareness of the increasing importance of science for the nation as a whole. Although science is inextricably mixed in our day to day living it is good to have occasions like this to remind us about what science stands for, to what extent we are taking advantage of what it has to offer, to what extent we are misusing it and above all whether we are doing enough for its popularisation and dissemination.

On this last count I recall, years ago, meeting an educated non-scientist friend returning from a public lecture by Professor Raman on **why the sky is blue**.^{*} I could sense my friend's excitement at the revelation of the mystery behind something that we observe every day. There were two aspects to this excitement - first that one can find a rational explanation for a natural phenomenon in terms of known laws of science. The second and in my friend's case the more important aspect was that he, a nonscientist, could understand the explanation - that a Nobel Laureate came down to his level of communication.

Before I return to this important aspect of science popularization let me say a few words on what science stands for. The question "Why is the sky blue?" is just one of the many that man has asked about nature. Out of such curiosity science was born. It is often thought that science evolved through the answers man found to such questions. But answers are only half the total story - there can be no answers unless there are questions! First discover a systematic pattern by observations of natural phenomena and then ask how that pattern comes about. These steps are as important as the eventual solution to the question. Science has progressed through an unending chain of observations, questions, answers, predictions, more observations, more questions and so on.

Predictions are very important to science. It is not enough for a scientist to come up with

^{*}This talk by Prof. Raman is reproduced in this report elsewhere

a theory that answers existing questions only. The theory must make new predictions which can be experimentally tested, observationally verified.

Let me give an example. Ancient records of stars and planets in the sky showed that planets move relative to the background of stars. Indeed the meaning of the Greek word 'planet' is wanderer. The word indicates a lack of regularity in the motion of planets. Why this irregularity? Why is Venus sometimes seen to set after the Sun and sometimes before? The mystery of planets could be resolved in human mind in two ways. One was to ascribe supernatural powers to planets which enabled them to wander at will. The second was to discover the hidden pattern behind their wanderings and then search for its cause. The first point of view still survives in the form of astrology. In modern times the claim that astrology is science has been tested by scientific methods on numerous occasions but no evidence has been found to substantiate it.

The second point of view led the Greeks to the epicyclic theory. Based on complicated series of geometrical constructions this theory had the predictive power in the sense that it could tell with reasonable accuracy where a planet like Venus would be at any given date. Nevertheless it was based on the wrong premise that Earth is fixed and the heavens revolve around it. Several centuries had to pass before Copernicus and Kepler arrived at the correct picture of how planets move round the sun.

The next question was "why?" Why do planets move round the Sun in elliptical orbits according to the rules found by Kepler? The question was answered by Isaac Newton: Newton's laws of motion and gravitation gave the mathematical description of planetary orbits which turned out to be exactly as Kepler found. So the wanderers in the sky were not possessed of supernatural powers but were constrained to move as per the laws of nature.

This historical sequence and its aftermath very well illustrates what science is all about. Unsolved mysteries may tempt one to look for a supernatural solution. This temptation must be resisted. One has to be patient and persistent in order to discover the correct law of nature to explain the mystery. And then one must make predictions for future. In the case of Newton's law of gravitation one such prediction was made by Newton's friend and contemporary Edmund Halley. Most of us having recently witnessed the passage of Halley's comet, I need not go into the details of this episode. Suffice it to say that Halley had noted the passages of comets at regular intervals in the past and argued that they were visitations of the same comet and that its trajectory around the Sun was determined by the law of gravitation. From this demonstration Halley proceeded to predict that the comet would next be sighted in 1759. The comet did arrive precisely as predicted and has continued to do so since.

The law of gravitation is universal - it applies to all material objects. Thus our feeling of weight, the falling down to Earth of bodies that are tossed up, tides in oceans, the motion of moon and planets, the internal equilibrium of a star like the Sun, the motions of stars in

galaxy and of galaxies in clusters are all examples of the operation of the law of gravitation.

This underlying sameness of a basic law of nature controlling a host of diverse phenomena is the main theme of my talk. As science progresses, it is found that there is unity beneath diversity. The same electromagnetic theory accounts for phenomena like thunder and lightning, the blueness of the sky, the colours of the rainbow, the chemical properties of various compounds, the structure of atoms and molecules, of solids, liquids and gases. The radioactivity of rocks, the power source in an atomic reactor, the explosion of a nuclear bomb or the answer to the long-standing question "What is the secret of solar power?" all lead to the same laws, those of nuclear matter.

How many fundamental laws of science are there? Until a few years ago their number was four; today the answer to the question is 'three.' This is because scientists have been able to combine two of them into one - electromagnetic and weak interactions are now seen to be components of a single electroweak interaction. To the layman this may not mean much; to the professional scientist following fundamental physics this implies a significant advance towards the goal of unification. Unification of all known fundamental laws into one was a goal Albert Einstein aspired to and which many leading physicists today are trying to attain. But, who knows, by the time they succeed in uniting all four laws, they may discover new ones!

This quest is typical of the never-ending march of science. It never ends because Nature has a tendency of presenting man with further mysteries when he has solved existing ones. This fact that science never leads to a complete answer to everything is an asset rather than a liability. For it keeps the subject alive with the excitement of new discoveries and anticipation of even more.

Pure curiosity apart, applications of science to useful ends have also motivated progress and contributed to this excitement. This is where we find science so much part and parcel of our day to day existence. We need scientific inputs to agriculture for our food, we need efficient scientific services to generate energy to cook that food. We rely upon its new discoveries for improving communications. In education, health, employment . . . all sectors of human welfare we cannot do without science. All such diverse applications, however, spring from the same basic knowledge of fundamental laws of science that I mentioned earlier.

For science to prosper in this country this excitement has to be conveyed to talented youngsters in schools so that at least some of them are motivated to go to a scientific career. A few years ago there used to be a National Science Talent Search Scheme which used to award scholarship to bright talented science oriented youngsters. More recently this was changed to National Talent Search Scheme, with the word 'science' dropped. In itself this is not a bad thing because the country needs talent in humanities as well as in science.

However, we Indians are good at generating anomalies in good-intentioned schemes! Coach-

ing classes have sprung up all over, training would-be aspirants in answering NTS test papers. How talent can be generated by coaching, I don't know. What is worse, these classes discourage students from offering mathematics or physics where on-the-spot thinking and originality are required and hence the scoring rate is low. Instead they are encouraged to go for geography, biology or civics where memorizing data can lead to high scores. This results in a shift from real talent to rote-learning. Such a scheme is hardly likely to encourage the talents of a C.V. Raman or a Rabindranath Tagore.

Would it not be more logical to have a test scheme that encourages original thinking and innovativeness so necessary for science? Can we not demonstrate to the youngsters that the joy of doing science lies in probing nature through thoughts and experiments? As it is, we only suppress whatever motivation they have for science under masses of unnecessary detail and rote-learning.

At the other end of school science the situation is equally dismal. The other day my five-year old daughter made the comment that she doesn't like science. Surprised and shocked at so definitive a statement at such an early age I asked her the reason. She brought out her class work book pointing to the words she had to correctly spell. These include necessary, measuring, breathing, resistance, every-where, muscles, recreation, vegetables, repaired and buffalo. Whatever curiosity a child of her age may possess is sure to be killed by a system of teaching that emphasizes memorizing difficult words rather than explaining facts about nature.

That's the experience of a child who goes to the first standard in our cherished Kendriya Vidyalaya system. Will the ivory towers in Shastri Bhawan and Aurobindo Marg take note?

The real thrill of doing science lies in discovering the hidden order and harmony that lies beneath masses of detail. It lies in turning those discoveries towards the betterment of human existence. Do we want to frighten the youngsters away from mathematics - the subject that helps the scientist discover that hidden order and harmony, the subject so essential to turning pure knowledge into useful technologies?

The joy of doing science can to some extent be shared also by the common man. More importantly, a society enlightened about science can influence decision making on how scientific knowledge is being used. For, misuse of science can generate problems of its own. Pollution from excessive and indiscriminate industrialization especially in urban areas is readily evident to the common man. Less obvious but potentially much more dangerous is the threat of nuclear weapons.

And, of course, it is because of the benefits of science that human death rate has come down and human life span has lengthened. As a result there is a tendency for populations to grow unless control is exercised on human birth rate. Since a country's resources are shared by its inhabitants, the standard of living of a typical citizen cannot rise unless the size of the population is kept under control. Some countries achieve this by compulsory legisla-

tion, others do it by voluntary methods offering incentives and relying on enlightened family planning by its citizens. In our country the need for population control is severe, but the milder second approach is followed. Although incentives and medical advances help, in the final analysis enlightened self-interest is what matters. It is therefore necessary to educate the masses on this issue.

Popularization and dissemination of science are therefore all the more important in our country. The print media, radio, TV, lectures, lecture demonstrations, science exhibitions, fairs, jattras and jathas are the means available and in use today. Several individuals and voluntary organizations are playing laudable roles in these fields. Of late the Government of India has set up the National Council for Science and Technology Communication (NCSTC) to co-ordinate and fund many such activities.

However, let me interject a word of caution. With the best of intentions an infrastructure may be set up by the Government in order to further a certain desirable activity. In practice although a lot appears to be done, much less is actually achieved. Let me cite my own experience! In 1982 I was asked to write a simple book on astronomy for children for the Nehru Bal Pustakalays of the National Book Trust of India. I wrote a book which was duly published and I am happy with the quality of production. But the trouble is, it is hard to get hold of this book in any book shop. The book has not been advertised properly nor has it been reviewed; as a result the potential readers do not know of its existence! What is the point of working hard on producing a book if it is not reaching those for whom it is intended? I had a similar frustrating experience with a Marathi popular book on astronomy which I wrote for the Maharashtra State Board of Literature. In short, although the annual reports of such organizations show that so many books were published, the main purpose of publication is not served.

Let me end this address on a positive note. It is heartening to see that the National Council for Science and Technology Communications has already established a good rapport with individuals and voluntary organizations dedicated to science popularization and the spread of scientific temper. Organizations like the Eklavya in Madhya Pradesh and the Kerala Shashtra Sahitya Parishad are playing a much needed role in these fields and their scope and numbers need to be increased. I therefore hope that guidance, encouragement and if necessary funds provided by NCSTC will go a long way in future years.

For, science by its very nature has built-in objectivity and universality that make it transcend caste, creed or social inequalities. Its dissemination is not only beneficial but essential for preserving the unity and increasing the prosperity of our country. On this National Science Day let us hope that through science and increased awakening of man's responsibility to life and nature will develop into a new sensitiveness for fruitful living — something that is worth dreaming about now that the twenty-first century is so near.