Science Musings:
Selected editorials from *DREAM 2047*

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Published by
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Science Musings: Selected editorials from DREAM 2047 by Vinay B. Kamble

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ISBN: 978-81-7480-203-3

Price: Rs. 200/-

Printed by: Viba Press Pvt. Ltd., Ph. 41611300

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Preface

As the title suggests, these are musings indeed, written for *Dream 2047,* the monthly popular science magazine-cum-newsletter of Vigyan Prasar. The selections in this compilation cover a wide spectrum of issues and events that were topical at the time of writing.

The readership of *Dream 2047* ranges from school students to general public, and those with science background. Further, it reaches out to the most interior regions and the remotest corners of the country where science magazines, let alone popular magazines, are difficult to come by. Of late, *Dream 2047* has assumed the status of USP for Vigyan Prasar.

Often *Dream 2047* is the only source of scientific information for those in the interior or the far flung areas of the country. It is for this reason that a conscious attempt is made to include historical and scientific facts in a simplified manner in each editorial. May be, this is what prompted a reader to comment that the editorials in *Dream 2047* are more like 'articles' than 'standard' editorials!

The present compilation of selected editorials includes the period 2001 to 2009. The topics cover diverse spheres of human activity; and the events that have greatly impacted and shaped our lives. Hence, they also represent a wagon wheel of how science and technology have forged ahead in this period. But, musings they are - from *Smashing Particles* to *Feeding the Hungry;* and from *Angels and Demons* to *Water on Moon*!

I am extremely grateful to the readers of *Dream 2047* who have read the editorials with interest and have time and again expressed their appreciation, thereby encouraging me to continue with my task. It was the encouragement of the readers and my colleagues at Vigyan Prasar that played a key role in bringing out this compilation. I do hope it would prove useful to those interested in knowing how science and technology continue to shape our lives and improve our understanding of the world around us.

I express my sincere thanks to my colleagues, Shri Rintu Nath and Dr. Subodh Mahanti for their enthusiasm and the immense efforts they have put in to bring out this publication. Shri Biman Basu, the celebrated science communicator and my friend, always was the first to read and comment on the contents of the editorials for their improvement. My sincere thanks to him. I also would like to mention my colleague Shri Muneesh Wadhwa, a commerce graduate, who read each of my editorials with immense interest. Once he okayed it, I felt re-assured about its readability. And finally my thanks to Shri Subhash Bhatt who designed *Dream 2047* every month and Shri Pradeep, who designed the book and the cover page.

Vinay B. Kamble
29 November 2009

Making Science More Assessible and Less Frightening

When we look back, especially at the last fifty years of the millennium gone by, we cannot help but feel a sense of pride and achievement. Our food production has more than matched the three-fold increase in the population. More than fifty per cent of our population can read and write (it could be much higher in the next census!). Availability of power has considerably gone up. There are more schools and colleges and hence better opportunities for education. Further, there also has been a general improvement in the quality of life - cooking gas and telephone connections are much easier to obtain, rail travel has become more comfortable, and so on and on.

New technologies are fast replacing the "what-were-once-new" technologies as they become obsolete. Just think, how fast the "latest" model of a computer purchased by you becomes obsolete, or how fast compact fluorescent lamps are replacing the good old tube lights. Well, this is how it should be. In the field of medicine, terms like ultrasonography, magnetic resonance imaging (MRI), organ transplant, and in-vitro fertilization have almost become a part of everyday life. Consider the advances in the field of biotechnology. Genetically modified food products, transgenic crops, cloning, gene replacement therapy, stem cell harvesting and similar jargon is fast becoming a part of our everyday vocabulary.

Let us look at the other side of the coin. Undoubtedly, the new technologies have helped improve the quality of life, thereby significantly changing our life-styles. However, it is also equally true that breakthroughs in the fields like biotechnology have instilled a sense of awe and fear - fear of the unknown - in our minds. Consider the question - are genetically modified food products safe to consume? Will transgenic plants with built-in pesticides give rise to a new breed of pests which are resistant to these built-in pesticides? How shall we tackle the problem then? What is the guarantee that gene replacement therapy would be used only for the human good? Would it not be misused to produce new Frankensteins? Indeed, most of us are totally ignorant of what the new science holds in store for us. Such doubts and questions make the task of realizing our dream - even in a small part - of every citizen with a scientific outlook a distant dream indeed! Under the circumstances, how shall we make the developments in science less frightening and more accessible to the people?

Indeed, people do possess a keen desire to know and understand the new science and new technologies as they become part of their lives. The innate curiosity and the thirst for knowledge always co-exist. Otherwise, over a century ago, people in Punjab would not have thronged to listen to Ruchiram Sahni's lectures by paying a fee of two annas, or the Albermarle street in London to listen to the discourses of Michael Faraday at the Royal Institution of Great Britain. A recent example is the overflowing Siri Fort auditorium in Delhi where people turned up in thousands to hear Stephen Hawking unravel the mysteries of the Universe and the black-holes. True, there can only be one Faraday, Sahni or Hawking. But, there certainly are thousands of mini-Sahnis, mini-Faradays or mini-Hawkings amongst us, in our labs, colleges, university departments, schools and Government / non-Government organizations who could take people into confidence and engage them in discussions and free debates. This is how developments in science would become more accessible to people, and at the same less frightening.

For scientists and science communicators, this is both a challenge and a social responsibility. How shall we take the bull by the horns? Please do write to us.

(January 2001)

Rising From the Rubble*

As the country was celebrating the 52nd Republic Day, the Earth shook violently in Gujarat sending tremors all over the country and all the way to Nepal and China. The cities and villages that stood testimony for centuries to the vicissitudes of history were reduced to a heap of rubble during those fateful two minutes. Even the cities far from the epicentre - Ahmedabad (300 kms) and Surat (400 kms) were not spared. Besides the thousands of human lives lost, the loss to livestock, property, houses and structures was enormous. Those who survived were not too fortunate either. Their world has completely changed.

The first phase of providing immediate relief in the form of shelter, food, medical treatment, clearing the debris, providing potable water, and fuel etc. would be completed in near future. Despite sympathies, and relief reaching them from all over the country and different parts of the world, it would be a long time, probably years before those affected could be successfully rehabilitated. The fear-psychosis and the trauma that have gripped the survivors, revival of their confidence in themselves, construction of earthquake-proof houses, continuing medical care of those left disabled, re-establishment of schools, offices and institutions, care of the orphaned children and their education, special attention to women who lost their families and their rehabilitation are but a few aspects Government and non-Government organisations will have to address their attention to.

* While India was celebrating the 55th Republic Day, a major earthquake struck Gujarat on 26 January 2001 at 0846 hrs. that left thousands dead and caused extensive damage.

Yet another aspect is that such calamities lead the affected people to reinforce their belief in fatalism and superstitions. It is both a duty and challenge to those engaged in the relief operations - and those engaged in science communication - to explain to them the difficulties involved in scientific predictions as a result of incomplete data or the incomplete understanding of the scientific phenomena. It is essential to establish once again their belief in science and scientific approach helping them resolve the conflict within - heart and head pulling in opposite directions.

It is unfortunate that the young science of seismology - dating back no more than a century - still cannot predict with certainty when and where the Earth will next shake and release its destructive energy from within. What science can now tell us is which areas on the Earth's surface are more prone to earthquakes. It is still more unfortunate that this knowledge was available but not used in Kutch. Nor has it been used in the North and the North-East, the regions more commonly associated with earthquake dangers in India. Although the location of future events of major seismic activity can be identified with some probability, the probability of success in locating their timing remains extremely low. The country cannot afford to go through the agonising trauma of another Gujarat. During floods and cyclones, at least we have some time to evacuate the people to safer places. Not so with earthquakes. This then is a sufficient reason why we need to launch vigorous programmes on "earthquake preparedness" in regions or zones identified as vulnerable to major earthquakes. There is not much time to lose.

Where do we begin? Here are a few suggestions: (1) Development, production and dissemination of educational packages, posters and publications giving scientific information on earthquake phenomena and on topics such as design of earthquake resistant houses, do's and don'ts to minimise the loss of human life and damage to property, and other relevant software; (2) Organise awareness campaigns/programmes giving scientific information and tips to minimise loss of life and property; (3) Development of core-groups especially in the earthquake prone regions and familiarising them with physical and emotional needs of the victims - educational, medical, housing and obtaining financial assistance to initiate a trade etc. and continuous rapport with scientific and Government/non-Government agencies for better co-ordination during relief operations and rehabilitation programmes; (4) Promotion of ham radio activity for establishment of emergency communication network. Incidentally, ham radio has proved its utility time and again during several natural calamities earlier and also during the present disaster. NCSTC/Vigyan Prasar ham radio station actively participated in establishing an emergency communication network with ham stations set up in the affected areas of Kutch and at other places; (5) Training of village persons in first-aid in collaboration with District and Village Panchayat authorities and Primary Health Centres and development of a medical kit for use during disasters; (6) Carrying out earthquake drills in schools and development of an earthquake survival kit; (7) Development of websites giving important and latest information on topics related to earthquake.

Meanwhile, Gujarat continues to feel tremors. Let us sympathise and empathise with the affected people, identify their problems and work for possible solutions, thereby helping them in the process of rehabilitation. Let us help Kutch rise from the rubble as fast as possible. We cannot avoid disasters, but we can learn to manage them.

(February 2001)

Investment In Real Terms

The map of life unfolded by the unravelling of the human genome in 2000 threw up quite a few surprises - the most crucial being that the difference in genomes between different races is minuscule, only 0.1 per cent; that is 99.9 per cent of all humans have the same DNA. This implies that there is no "superior" race on this planet. The other surprise was that the number of human genes are actually much less than estimated earlier - only about 30,000 as against the initial estimate of 100,000. This is just twice as much as the number of genes that make up a fruit fly! Further, the large tracts of human DNA which don't contain any genetic material (also called desert regions or junk DNA), may not be garbage after all. What is striking is the fact that we are a product of the unique orchestration of our genes, proteins, pre-historic bacteria and environment. May be, it is this environmental factor that let hundreds of bacterial genes find their way into human genome and not through evolution. In addition, the belief that one gene is responsible for one protein no longer holds. It is now thought that it is actually a network with control genes kicking other genes into life to make proteins. Instead of producing only one protein per gene, the average human gene produces three different proteins!

In February 2001, the Near Earth Asteroid Rendezvous - Shoemaker spacecraft touched down on Eros, the kidney-bean shaped asteroid, or the geologic relic formed some 4.5 billion years ago and more than 300 million kilometres from the Earth, ending journey of some 3 billion kilometres and a full year in its orbit. Eros belongs to a group of large asteroids with orbits relatively close to the Earth, like the one which is believed to have slammed into the Earth and wiped out dinosaurs some 65 million years ago. The data has given scientists clues about the history of solar system and work out means of averting such catastrophes in future.

No doubt, all that is great news for science, and full of excitement. Whether it is the universe outside the Earth, or inside the living cell, it is bound to fire anybody's imagination. What is intriguing is the fact that why does it fail to fire the imagination of our younger generation? What makes our students turn Nelson's eye towards a scientific career? One reason oft-quoted is that science is no more a lucrative profession! But, the crux of the matter is our school children are rarely exposed to the excitement of science. They are unaware of the challenges and thrills offered by a scientific career. In the absence of such an exposure, no wonder students shy away from this challenging profession. The warning bells have already started tolling. It is becoming increasingly difficult to recruit the right type of scientific personnel in our R&D labs, universities, and even science teachers in schools. Given that the social and economic development of a country depends on how strong its scientific base is, it becomes all the more imperative to convey the thrill and excitement that a scientific career offers to our children, especially at secondary and senior secondary levels.

What is the remedy, then? A few years ago, the Indian Institute of Science, Bangalore, evolved a programme of Extension Lectures in Science and Engineering by the faculty members of the institute on modern scientific developments in schools and colleges within a radius of 500 kilometres from Bangalore. The lectures are delivered on voluntary basis by the faculty members in addition to their regular academic and research commitments and are supported by demonstrations, slides or models. The schools/colleges need only play the host and organise the lectures, the travel and other expenses being borne by the institute. The programme has proved to be immensely popular and effective in triggering an interest in science among the children, and at the same time encouraging them take up a scientific career in their chosen areas. The lectures, if brought out in the printed form - especially in the local languages, would go a long way in furthering this noble effort. It is high time scientists from our R&D labs, universities and industries also followed the suit with active support from their respective organisations. Indeed, this would be an investment in real terms for the social and economic growth of the country.

(March 2001)

Literacy Campaigns - A Decade Later

In May 2000, we celebrated the birth of Astha, the billionth baby of the country. Ever Since, we have added another 27 million babies taking the population of the country to 1.027 billion. In the year 1991, our population stood at 866 million, however, there has been an addition of 161 million persons during the decade 1991-2001. The annual growth rate still hovers around 2 per cent. But, every cloud has a silver lining. There is something to cheer about, as the provisional results of the census of India 2001 indicate. Today 65 per cent of country's citizens can read and write, compared to 52 per cent in 1991. Nearly 76 per cent of the males and 54 per cent of females are literate today, in 1991 their per centage stood at 64 and 39 respectively. This implies that more than three fourths of the males and more than half of the females can read and write today. What is more, there has been a net decline in the "absolute" number of illiterates during 1991-2001.

Undoubtedly, the spectacular growth in the literacy rates has been a result of the major initiative during the last decade in the area of adult literacy by organisations like the Kerala Sastra Sahitya Parishad and backed by the People's Science Movement. With the setting up of the National Literacy Mission in 1989, and formation of Bharat Gyan Vigyan Samiti by the constituent organisations of People's Science Movement, the effort spread to the entire country in the form of Total Literacy Campaign in various districts. In fact by 1997, the campaign spread to some 400 districts. There is no gainsaying the fact that the literacy growth rate achieved during this period was a direct result of the voluntary and mass involvement of over ten million volunteers.

An important fall out of the literacy campaigns was the demand by parents for the education of their children. The recent efforts of the Department of Elementary Education and Literacy include initiatives like the Sarva Shiksha Abhiyan to provide elementary schooling to all children in the age-group 6-10 years by 2010, extension of the District Primary Education Programme aimed at Universalisation of Primary Education, Education Guarantee schemes for out-of-school children, and the third phase of Lok Jumbish and Shiksha Karmi projects for improving the quality of elementary education. As regards the Adult Education, the National Literacy Mission would be revitalized with an aim to attain full literacy in the age-group 15-35 years by 2005. Further, Continuing Education Centres for life long learning in all villages and more Jan Shikshan Sansthans to promote vocational and skill development programmes for neo-literates are also planned to be set up.

Despite the fact that the above initiatives owe their origin to the Government, to translate them into a concerted effort to accomplish the stated goals of total literacy by 2005, in the age group 15-35 years, it would be necessary to build upon the experience gained in the decade gone by. First and foremost, it would be imperative to ensure that the literacy campaigns essentially maintain the participatory nature of a people's movement, as it did during 1990-2000, with its army of volunteers from various Government/non-Government organisations and motivated individuals, which interacted and maintained a close contact with the beneficiaries. Government and voluntary organisations will need to work hand-in-hand for the purpose. Further, to prevent the skills acquired by the neo-literates from being lost, it is required that the same be utilised to understand and appreciate the issues directly affecting their lives - these may include issues like health, environment, sanitation and hygiene, nutrition, appropriate technology, agriculture and so on. In addition, a conscious effort would be needed to inculcate a scientific temper among them. This calls for continuous post-literacy follow-up activities with the neo-literates, and an evaluation of methods, structures and the primers developed till date for suitability and propriety of such materials, and their improvement. Otherwise, there is every likelihood that the neo-literates would lose the skills acquired and fall back into the trap of illiteracy, thereby negating the progress thus far.

What is described above is really a ready-made opportunity for the constituents of the Vigyan Prasar Network (VIPNET) of science clubs to contribute their might and be an integral part of the literacy campaigns and activities like the Sarva Shiksha Abhiyan. The clubs could engage themselves in a few of the activities outlined above with the neo-literates. Then our cherished goals of total literacy, inculcation of scientific temper and self-reliance will not look too distant a dream. Please do write to us how we could together contribute to the effort. We still have a long way to go.

(April 2001)

Quest for Self-Reliance*

A feeling of despair swept across the nation when the launch of the Geosynchronous Satellite Launch Vehicle (GSLV) was aborted on 28 March 2001, just a second before it was to lift off, as one of the strap-on engines failed to derive the necessary thrust. However, the bright spot was that the safety mechanism worked well, and the launch vehicle was saved. 18 April 2001, barely three weeks later, highlighted the ability of nation's scientists to handle complex systems, when the GSLV blazed into the afternoon sky. Undoubtedly, they were the longest seventeen minutes for those who had contributed towards the fruition of a four-decade dream of Vikram Sarabhai. It was also a testimony to the ability of ISRO that it can quickly and accurately identify its mistakes and correct them. The Geosynchronous Satellite (GSAT-1) was injected into the Geotransfer Orbit as planned. But, soon after it was discovered that the farthest distance from the Earth after the launch was slightly less than 36,000 kms which should have been achieved. In addition, the orbital inclination, that is, the angle at which the satellite's orbit is inclined to the equator - was 19.2 degrees, compared to 19 degrees planned for. Compensating for these shortfalls required the use of on-board propellant which was meant for fine orbit trimming operations that need to be carried out throughout the life time of the Geosynchronous Satellite after it has reached its final home in orbit. As a result, the life of the satellite gets considerably reduced. Still, all seemed

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* *GSAT*-1 was India's first home-made geosynchronous experimental satellite launched by ISRO for performance monitoring. Subsequently ISRO launched *GSAT*-2 Communication Satellite on 8 May 2003.

well. But, the on-board propellant soon got depleted due to the unequal consumption of fuels stored in two tanks. The result was a “drift” orbit, which led to GSAT-1 circling the Earth once in every 23 hours, drifting at the rate of 13 degrees a day instead of being in a geostationary orbit matching the Earth’s rotation. Despite the fact that the satellite is in excellent condition, it would be visible only for 10 days in a month when the payloads, that is, the on-board equipment could be switched on for testing purposes. GSAT-1 was to be used for demonstrating digital audio broadcasts, internet services, compressed digital TV experiments and developmental communication.

Indeed, the first flight test of GSLV was intended to validate the various systems of the vehicle in an actual flight. Though each of the subsystems had been tested on ground, it is only through a few developmental tests that the launch vehicle, as a whole, and all the associated ground systems could be validated. The project faced quite a few hurdles ranging from U.S. technology sanctions and cost overruns to supply (or non-supply!) of the appropriate cryogenic engine technology from Russia. In any case, the question still remains: what caused the underperformance of the GSLV? One reason could be the imported Russian cryogenic engine which was only ground-tested and had never before flown on any launch vehicle, could not impart the requisite velocity to GSAT-1. The other reason could be the rocket’s guidance and navigation system that may need to be improved upon.

In any case, GSAT drift is only a temporary set back. We shall have to take it in its stride. One should look at it from the point of view that it has taken the country further from having had to abandon the GSLV flight earlier. If the drift has raised doubts about the satellite’s usability, we shall have to resolutely move ahead in our pursuit for achieving perfection for GSAT to be completely error-proof. In addition, the success would give the Indian space establishment the confidence to proceed with its own development in cryogenic technology and indigenise it further. Today, we need engines that can lift much heavier satellites than GSAT-1. But, it has rarely happened that any country had a successful launch of a geosynchronous satellite at the first attempt. If they have become self-reliant in space technology today, it is through their own individual efforts. We, too, have no alternative.

But, the most important factor in the quest for self-reliance is attracting and retaining young and creative minds, and allowing them the freedom to tinker around. This process must begin at the school level. In this regard, it would be worth exposing school children to the exciting world of space science and its applications through activities like model rocketry, astronomy, amateur radio, and so on. Our quest for self-reliance could begin at school level. VIPNET clubs could play a significant role in accomplishing this goal.

(May 2001)

Predicting the Future

The celebrated British physicist Stephen Hawking was in Delhi on 17 January 2001 to deliver the Albert Einstein Lecture 2001. Interestingly, The topic of his lecture was "Predicting the Future: From Astrology to Black Holes". In his characteristics style he said, "the reason most scientists don't believe in astrology is that it is not consistent with our theories which have been tested by experiment". This implies that for a subject to be projected as science, it is necessary to examine whether it follows the scientific discipline by making specific assumption on which it rests. It also follows that the predictions need to be accompanied by tests to approve them right. Indeed, this is how science & society have progressed. Sometimes, the basic ideas or assumptions on which the theory is based, may need to be modified or even discarded when more accurate observations are found to be going against them. An example is the Newtonian gravity. Though highly successful, is no gainsaying the fact that a scientific prediction is always characterised by a principle that a provable.

Astrology has been here for centuries, and continues to fascinate the human beings, many of whom even scrupulously regulate their daily activities based on their astrological forecasts. How is it that we wait for the Sunday newspapers for our weekly forecasts? Despite the overwhelming scientific evidence that the positions of the planets and the times of birth do not dictate the course of human affairs, astrology will be with us in the foreseeable future. Why is it so? Given the unpredictable turns in the lives of the individual, often chaotic, most of us long for the comfort of having guidance in making decision. It gives a heady feeling when an astrologer tells us that our personal character and destiny are tied up with the stars- of course for a fee! Further, it is so convenient to blame our failures on cosmic events that are beyond our control! It is this urge to seek correlations between the unpredictable turns in the lives of the individuals and regular movements of the planets that astrology came into being.

Even five centuries after Nikolaus Copernicus, astrologers continue to base their predictions on the assumption that the Earth is at the centre of the universe. In Vedic astrology, the "planets" include the Sun, the Moon, Mercury, Venus, Mars, Jupiter, Saturn and Rahu and Ketu. Incidentally, Rahu and Ketu do not even have any physical existence. Uranus, Neptune and Pluto even after that were discovered, have failed to secure a place in this list. Despite the assumptions at variance with the established knowledge, the horoscopes of individuals are expected to predict their future accurately. Did all those who perished in the recent Gujarat Earthquake have this unfortunate event predicted in their horoscopes? May be, it would be worthwhile instituting a study for a purpose. A famous astrologer states that in astrological predictions what matters is "intuition" - more than anything else. Obviously there is no way to test a theory based on assumptions that are not well-defined or rely on one's intuition alone!

Indeed, astrology has played an important role in the growth and development of human understanding of natural phenomena. The study of planetary motions was prompted by the demands of astrology for determining planetary positions with greater accuracy. Just the way alchemy led to the study of chemistry, astrology led to the study of astronomy. Astrology had its influence on human history as well, the study of which could certainly be relevant and useful.

However, it must be remembered that all scientific disciplines derive their legitimacy from the scientific method, the foundations of which include a respect for data, consistent reasoning, observational checks and the possibility of experimental refutation. At this juncture one may ask, with an "open mind", if the method or practice of astrology conforms to the method of science.

(June 2001)

Clones - It's Human Beings Now

The term clone, in everyday usage, refers to a group of organisms that are genetically identical. Most such clones result from asexual reproduction, a process in which a new organism develops from only one parent. Thus, all the offspring of a single parent form a clone. An experimental technique developed involves destroying the nucleus of an egg cell of the species to be cloned. The nucleus is then removed from a body cell of an animal of the same species. This donor nucleus is injected into the egg cell. The egg, with its new nucleus, develops into an animal that has the same genetic make up as the donor. If a number of eggs receive transplants from the same donor, the resulting offspring form a clones. This technique was used to clone such amphibians as frogs and salamanders as early as 1950's. However, the source for body cells and the nuclei was an embryo consisting of only a few thousand cells, because at that stage of development an embryo's cells are relatively unspecialized. As an embryo develops into a completely developed organism consisting of billions of cells, its cells become increasingly specialized. Some cells become skin cells, while others become blood cells. Skin cells can normally make only more skin cells, and blood cells can normally make only blood cells. By contrast, each of the unspecialized cells of an early embryo is capable of producing an entire body. In 1996, however, researchers led by embryologist Ian Helmut of the Roslin Institute near Edinburgh, Scotland, found a way to do the seemingly impossible. Mammary-gland cells from an adult sheep were placed in a solution that essentially starved them of nutrients and caused them to stop growing for a few days. Then, they fused each mammary cell with an egg cell from which nucleus was removed. The resulting cells were allowed to grow into embryos, which were then transplanted into a surrogate mother ewe (female sheep) to complete their development. Nearly 300 attempts resulted in failure. Some eggs did not accept mammary cell nuclei, embryos that were produced died, and lambs that were born were abnormal and died. But, one lamb, apparently healthy, survived the procedure: Dolly, who was born in July 1996. Later, besides pigs and sheep, scientists in different parts of the world cloned other animals, including cows, pigs and mice.

Surely, it is only a matter of time before human cloning becomes a reality. Well, the day does not seem to be very far. Two maverick scientists have unveiled their plans to produce the first cloned human beings by the end of 2002. They declared their plans recently at a panel brought together by the U.S. National Academy of Sciences for a report exploring the use of human cloning in basic science and medicine, such as the creation of tissues for transplants. The group led by Severino Antinori, an Italian fertility specialist, and his colleague Panos Zavos of the Andrology Institute in Kentuky, formally announced that his team would begin creating cloned embryos within a month or so. They would treat 200 couples suffering from fertility problems starting in November 2001. This generated a heated debate on ethical and legal issues related to human cloning, But, safety emerged as the key issue.

Many scientists felt that human cloning would be a hasty step before mastering the techniques of animal cloning and solutions to the health problems often exhibited by the cloned animals, as it happened during the trials before Dolly's birth. Again, Ian Helmut gave examples of two animals, one sheep and one cow, that appeared healthy at birth, but later died from lung and immune system disorders respectively. These would have been nearly impossible to diagnosis in utero. Because of such and several other unresolved issues, many scientists feel that human cloning should be postponed until these questions were answered.

Would a human clone tend to have a diminished sense of individuality? Would cloing undermine basic elements of a loving nurturing family, such as the acceptance of each child as a unique individual? What would happen to a world that separated reproduction from love and other human relationships? Would society use cloning to modify the human race, say, for warfare or slavery? Would doctors use clones as sources of organs for organ transplants? True, these concerns are genuine, but, we have no answer to them as of now. Perhaps the strongest argument advanced in favour of human cloning is that cloning could provide the only avenue available to some infertile couples for producing children. In cases of fertile couples in which one member carries a gene for a disease, cloning using a cell from the other member could assure that the couple has a healthy child of its own. Further, a clone would not really be a duplicate, but, only a delayed identical twin because environmental factors would mould him or her into a unique individual.

This is where we have arrived at from the days of Darwin. Cloning technology like any other technology, has two facets. How do we ensure that human cloning technology turns out to be a blessing? How would it affect the Indian society? It is only a few years before human cloning becomes a part of our lives. How shall we cope with it then? Before deciding a course of action, it would be imperative to take people in confidence and involve them in the decision making process . This topic must, therefore, be dealt with as part of peoples' science movement. Let us talk to the people, initiate debates and then arrive at a consensus. Human clones are round the corner!

(August 2001)

Child Prodigies

Tathagat Avtar Tulsi cleared his class X examination in 1996 at the age of nine, B.Sc. in 1997 at ten, and M.Sc. in 1999 in Physics with a first class at twelve from Patna University. In Decemb.er 2000, before he turned fourteen, he qualified for the lectureship by clearing the National Eligibility Test conducted by CSIR / UGC. He was a member of a team of young scientists / research scholars which visited Germany last June for an interaction with Physics Nobel Laureates. According to some media reports, it appeared that he was forced to memorise a lot of Physics jargon without knowing their significance. When he returned from his sojourn in Germany, the tag of fake was attached to him by the media.Tathagat has a burning desire - fuelled by his father - to be the youngest Nobel Laureate. His father claims that Tathagat has been a result of his sustained and painstaking experiments - governed by his private science of unproven assumptions!

In any case, there is no doubt that Tathagat's academic achievements are truly remarkable. He may not have been a prodigy he is made out to be, but, he is apparently gifted with intelligence rarely matched by children of his age. A parallel but lesser known case is that of Akrit Pran Jaswal, reported in the newspapers recently. His father, an economist who wanted to study medicine himself, made a decision for Akrit. Akrit was taken to a house in Himachal Pradesh, where he could concentrate on medicine. At seven years of age, he wants to study both neurology and oncology, and find cures for all types of cancer. But, whether it is Tathagat or Akrit, one thing is clear: pushy parents parading their children as prodigies are primarily fulfilling their own needs, and that whatever the potential of the child, he / she is performing on command, as some psychiatrists opine.

As a matter of fact, there have been exceptionally gifted children in the limelight over the years, all tauted as. child prodigies. Take the example of Mousumi Biswas of Purulia, West Bengal, who holds the record for clearing the class X examination at the age of eight years and seven months, or eleven year old Aarti Jajjoo who cleared the class XII examination conducted by the Rajasthan State Board. Or, remember the four year old Ajay Puri who has already mastered several computer software programmes? What is common with most of these children? They have someone marketing them, often their own parents, taking advantage of people's fascination with things not commonly seen or heard. In most cases, however, it is the parent's choice which is thrust upon these gifted children, with no consideration to their special needs. Under the circumstances, not only the brittle sensitivity of a child gets hurt, but, the child may not even be able to achieve his / her true potential. One psychiatrist points out that if a child is isolated, the child will do as he / she is taught. If the child sees the same thing every moment of his / her life, the child will retain only that. It is hence imperative that parents are careful to always provide their child with a choice. However, it is a fact that some of the greatest minds in science like Thomas Alva Edison and Albert Einstein had a highly unexceptional childhood. Indeed, they had to toil hard to attain their goals. At the same time, acknowledged child prodigies like Mozart and Beethoven continued to hold forth. It is also true that a large number of child prodigies begin to fade out as they grow and turn into adults. By then, other "ordinary" children catch up with them and then the realisation that you are no better than the rest may prove to be devastating. We do hope that Tathagat and Akrit do not have to face a similar situation. Let these bright children not fade into oblivion.

Finally, let us have a look at our own children. Don't we push our children, sometimes even beyond their capacities - just the way Tathagat or Akrit are being pushed? Our goal may not be a Nobel for the child. It could be to make it to a professional course like engineering or medicine! How often do we allow a choice to our children? Aren't we doing harm than any good to them by trying to determine their lives? At eight or nine, a child must have a childhood. Later, a child must have adolescence. During the process of growth, one must pass through all the stages in a normal way. It is imperative that we refrain from stressing one dimension of personality and overlooking others consciously avoiding any hype or hoopla to get publicity. A child is emotionally unprepared to manage the limelight that falls on him / her. There is a danger a child may start identifying himself / herself from the headlines in the newspapers - and before we realise, a push may turn into a shove! Let us refrain from trying to determine the lives of our children.

(September 2001)

No Longer Hypothetical

Not even a month had elapsed since the deadly attacks on the World Trade Centre twin towers in which thousands perished, when the fear of yet another attack gripped the 'U.S. But, this time it was a different story altogether. It was the human exposure to the dreaded anthrax bacteria that escalated the long-felt fears of the possible deployment and use of biological weapons in warfare. Now it seems that this fear is no longer hypothetical.

Till a few years ago, talks on chemical or biological terrorism began this way: "if a chemical or biological attack were to take place "! The attack on the Tokyo subway system in 1995 in which the nerve gas sarin was unleashed by the Aum Shinrikyo cult, preceded by the one in 1994 against the city of Matsumoto, changed all that. If a chemical attack is frightening, a biological weapon poses a worse nightmare. The small quantity of anthrax needed for a lethal inhalation dose can be easily concealed, transported and disseminated. Odourless and invisible, it makes a very stealthy killer. In theory, a kilogram can eradicate hundreds of thousands of individuals living in a metropolitan area, but for the inactivation or degradation when released in the environment. Further, anthrax spores can be stored for decades without losing their viability. Unlike chemical agents which are inanimate, bacteria and viruses may be contagious and reproductive. If they become established in the environment, they may multiply and unlike any other weapon, may become more dangerous over time.

Certain biological agents incapacitate, whereas others kill. Biological weapons can range in lethality from salmonella used to temporarily incapacitate to super bubonic plague engineered for mass casualties. Biological agents may be used to kill or disable humans or to attack plants or animals to harm a nation's economy. The Ebola virus, for example, kills as many as ninety per cent of its victims in about a week. For Ebola, there is no cure, no treatment. Biological weapons may include even toxins which are deadly substances originally produced by living organisms.

What is alarming is the fact that production of biological or chemical warfare agents is certainly within the reach of a dedicated and skilled group, and it does not require the resources or the technical assistance of the State. Much or all of the necessary production equipment and technology is available in the open market. Many deadly agents, including anthrax and plague can be found in nature. Given an initial biological culture, anyone who can brew beer can probably grow biological warfare agents. Even so, the entire process of producing and disseminating chemical or biological agents is not so trivial, and may require certain degree of knowledge and skill. Making biological weapons requires sample cultures; the means to grow, purify, and stabilize them; and the means to reliably disseminate them. In fact, it is said that in some countries, efforts are already on to build arsenals of biological weapons. Further, advances in genetic engineering and molecular biology could make it possible to develop a "superpathogen" in a laboratory resistant to any known drugs or antibiotics.

Given that there are at least some people or groups in the world who would actually use these agents against civilians, what could be done? True, this is hitherto an unknown dimension of warfare. To effectively counter the terror of these germs of war, it would be necessary to exchange information and resources in a coordinated manner. When a biological attack takes place, what is required is the information on the source of the agent causing these attacks on the individuals, charting out of preventive measures, and a high level of preparedness to face up to the challenge posed by the microorganisms released. It is equally important to initiate coordinated international efforts to curb the possibility of terrorist groups either developing or gaining control over chemical or biological weapons.

Most important, it would be imperative to improve the public health infrastructure in the country, Bhopal gas tragedy; and dengue and plague epidemics that broke out a few years ago in our country (hope they were not acts of bio-terrorism!); provided a glimpse of what a chemical or a biological warfare could be like. Remember to what extent the public and private health systems got stretched? Remember the fear and panic caused on all these occasions? In order that we are not caught unprepared, we need to begin drawing up contingency plans and formulate a comprehensive public health policy to counter such attacks. This may include replenishing expired stocks of vaccines and drugs (they have a limited shelf-life!), antidotes, replacing obsolete or expired equipment and so on. In addition, it would be necessary to pursue development of equipment to detect and identify the chemical or biological agents, to protect individuals from exposure, to decontaminate affected people, equipment and locations, and to provide medical treatment to the victims. We can perhaps never eliminate the possibility of chemical or biological terrorist attacks, but these activities will make us better equipped to respond to one, should it ever occur.

There is no gainsaying the fact that the vigil and the public confidence are of paramount importance in countering any chemical or biological attacks. This is possible only through a massive information campaign using all the media at our disposal, and through public lectures/

demonstrations encompassing aspects like basic information on agents used in chemical and biological warfare, preventive measures, and responding to the attack should the prevention fail. For science communicators, this is both a challenge and responsibility. Let us get on with it. The threat is real.

(October 2001)

Save That Drop

Water is a resource that defines not just the limits of sustainable development, but the very survival of human beings on this planet - the only planet known that supports life. The supply of fresh water is essentially limited, and the demands on available quantity of water have already reached precarious proportions. While the global population has tripled over the past seventy years, the use of water has grown six-fold! Only about 2.5 per cent of all water on the planet is fresh water which is essential for all human purposes - but only about 0.5 per cent is accessible ground water or surface water. World-wide, 54% of the annual available fresh water is being used at present. Assuming that the consumption per person remains steady, by 2025 we could be using 70% of the total because of population growth alone!

The World Population Report 2001 estimates that by 2025, as many as 3 billion people from 48 developing countries (India included!) will suffer from levels of water scarcity which may be acute to desperate! The world population today stands at 6.1 billion - twice the number it was in 1960. In 2000, 2.1 billion people from 61 countries were using less water than a basic daily requirement of 50 litres per capita per day. By 2050, 4.2 billion people accounting for about 45 per cent of the humanity will be living in countries that cannot meet the requirement of 50 litres of water per person each day! Incidentally, this minimal standard does not take into account other necessary uses of water - for agriculture, protection of ecosystem and industry.

There is no gainsaying the fact that the burden of the acute shortage of water is borne by the poor, especially in the far-flung rural areas. We continue to read the stories of our women in the rural areas trudging for several hours just for a pitcher or two of drinking water! The situation is worse in summer months. Cities are no exception either. With urban population increasing as a result of migration from rural areas, the municipal taps go dry for longer and longer periods every passing summer.

Why have we landed up in such a grim scenario? The reasons are not difficult to find. Despite the fact that the available ground water is limited, it has been recklessly exploited over the years. We have also forgotten the traditional methods of rainwater harvesting, with few attempts to recharge the aquifers. Many countries, including India, use unsustainable means to meet their water needs. If more water is drawn than is replenished by natural processes, the excess is essentially "mined" from reserves. Agriculture and industry, in particular, divert large amounts of water with disastrous effects at times. Finally, there is the additional problem of pollution, especially in the developing countries like India. 90 per cent of sewage and 70 per cent of industrial waste is dumped annually into the surface water sources, especially the rivers and lakes. Alarming, indeed! No technology can increase the amount of fresh water available naturally. The quantity of water available today is the same as it was some 2000 years ago, when the world population was barely 3 per cent of today's 6.1 billion! Purely technological solutions to water scarcity are unlikely to have any significant effect. Desalinized sea-water is expensive. It now accounts for less than one per cent of the water people consume.

What is the solution then? Protecting water supplies from pollutants, restoring natural flow patterns to river systems, managing irrigation and chemical use, and curbing industrial pollution are vital steps to improving water quality and availability. In addition, what is needed is the revival of traditional water harvesting techniques. Surely, it would be too much to expect Government alone to accomplish much. It would require a continued joint effort by the Government and the people - especially through those non-Government organisations which are already engaged in promoting traditional water conserving techniques. This is only one aspect. The other aspect concerns concerted efforts at controlling the growth of population, educating the people on the importance and use of conservation techniques, and minimizing the pollution of water. True, this is a formidable task and a formidable challenge of the present century to science communicators. Indeed, this needs to become a part of the People's Science Movement. Let us save that drop of water we have borrowed from our children!

(November 2001)

Popularizing Science Through Matri-Bhasha

Phenomenal growth in literacy ratio over the years, a higher level of general awareness among the people, and their growing participation in the decision making process have posed new challenges to science communicators in their tasks. With nearly three-fourths of the males and over half of the females being literate, the next step would be to help them understand and appreciate issues directly affecting their lives which may include issues like health, environment, sanitation and hygiene, nutrition, appropriate technology, means of income generation and the like; and that too without any conscious effort to inculcate a scientific temper among them. In order to bring them into the national mainstream, however, it would be necessary to put in efforts to help them attain a level when they can read newspapers / magazines with sufficient ease.

When we read a newspaper, we can follow with ease, understand, and interpret news items related to education, sports, politics and so on. If we can understand with the same ease news items / articles on topics like PSLV and GSLV launches, genetically modified foods, use of CNG for transport, anthrax as a biological weapon and so on, it could be said that we are scientifically literate. It is then that one can actively participate in the decision making process. This, however, implies information on and understanding of recent scientific developments and working knowledge of gadgets we come across in our daily lives. It may also require familiarity with a few scientific principles and natural phenomena. For example, information about AIDS or Dengue and how they spread could help us keep them at bay. Knowledge and information about ORS (oral rehydration solution) could help save lives of thousands of infants. The challenge before science communicators is then imparting information on and interpreting such items and issues in a language and manner acceptable to the people.

However, imparting or acquiring information alone would serve little purpose. It is necessary to help people learn to organize, analyze and apply the information to arrive at a solution and understand the environment they live in - physical or social. Whatever the topic and whatever the media, scientific approach must reflect in the articles we write or radio / television programmes we produce. This means balanced reporting with objective analysis of different news rather than one-sided view or a story with hype and sensationalism. Media are expected to act as a mirror - be it newspaper, radio or TV - and reflect the true picture of the society; but this is possible only if the mirror itself is not distorted.

Making people scientifically literate, however, does not imply reproducing articles from research journals in local newspapers alone or translating them into a language even a person well versed in that language may find difficult to comprehend! A major effort is therefore called for to simplify the language of communication and develop terminology with words and phrases employed in daily life. Sometimes it is desirable to retain the original terms as they are if they have already been accepted in the language of translation rather than attempt a contrived translation (say Vikiranadharmita for radioactivity or Gandhakamla for sulphuric acid). There is no gainsaying the fact that every region speaking a particular language will have to evolve its own language with local nuances for science communication whatever the media employed. What is more, we shall have to learn to think in Matri-Bhasha if we hope to communicate science and technology to the people effectively.

Original articles / books written in one regional language also may need to be translated into other regional languages. Maybe we shall need to set up translation bureaus for this purpose as suggested by Shri M. V. Kamath, well known journalist, and President, Vigyan Prasar, in a recent meeting on science communication in Marathi at Mumbai. It is heartening to note that leading scientists like Professor J. V. Narlikar and a few others have taken upon themselves the task of taking science to the people in regional languages with a missionary zeal, and have inspired a whole lot of the younger generation to follow the suit. Of late, there has been a discernible growth in publication of popular science books / magazines in the regional languages. Government agencies like NBT, NCSTC, Vigyan Prasar, and several non-Government organisations have also significantly contributed to accelerate the process.

Many of us – scientists, science communicators, social workers, students, teachers, administrators, etc., have been actively engaged in a variety of societal problems in a bid to transform our country into a nation of not just literate, but scientifically literate and scientifically minded people. For this purpose, it is imperative that we start thinking and writing in Matri-Bhasha.

(December 2001)

Attaining Criticality

The Scientific Policy Resolution of 1958 recognised the importance of "encouraging individual initiative for the acquisition and demonstration of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom". Much later, a clause in the Article 51A of the Constitution of India was included that read, "it shall be the duty of every citizen of India to develop scientific temper, humanism and spirit of inquiry and reform". However, "the growing need to enhance public awareness of the importance of science and technology in the everyday life", and the special support of the Government "for programmes that seek to popularize and promote science and technology in all parts of the country" has been clearly spelt out only in the draft science and technology policy document 2001 (version 3). Indeed, this is highly encouraging!

During the pre-independence days, popularization of science was largely limited to a few motivated individuals with a missionary zeal - be it Ruchiram Sahni, Jagadis Chandra Bose or Sir C. V. Raman. They could electrify the audience with their remarkable gift of simplifying the complex phenomena interspersed with simple demonstrations, and attract the young to the world of science.

Not that the Government did not realize the need for scientific awareness soon after the independence. The Department of Education had set up in late fifties a few Vigyan Kendras especially in rural areas. In Gujarat there were two, and one was very close to Junagadh, which I used to frequent as a child. It used to be more a museum than an activity centre manned by a young science post-graduate. However, within a decade or so, the Vigyan Kendras mysteriously vanished! One wonders how and why!

In the sixties, the Kerala Sastra Sahitya Parishat took upon itself the mantle of science popularization as a social responsibility. It was around this time that a few voluntary organizations like Community Science Centre (later renamed Vikram A. Sarabhai Community Science Centre), Ahmedabad, came into being with the sole aim of popularizing science. Seventies marked the establishment of the National Council of Science Museums with its chain of science museums, and was probably the first conscious effort at popularization of science in the country. A concerted, co-ordinated effort for science and technology popularization started when the National Council for Science and Technology Communication was established in 1984. Soon after, the level of S & T popularization activities in the country grew rapidly, and so did the number of voluntary organizations engaged in the field, a welcome sign indeed.

One is however, disappointed to find that, though the level of science popularization activities has significantly grown over the last one and a half decades, it still has continued to be at a sub-critical level. One reason is that most voluntary agencies engaged in S & T popularization find it difficult to make both ends meet. The new Science & Technology policy could come to their rescue in this regard. Further, there is no gainsaying the fact that the young graduates do not find the job lucrative. Next, after a few years of existence, an organization invariably falls into the trap of routine, stereo-typed activities and hence monotony, having exhausted ideas and initiatives. No longer does one find the job exciting and challenging. It is then that such organizations need a fresh breath of air. Who could provide it? Surely, the mantle falls on the established scientists and science communicators to offer them a fresh lease of life in terms of new ideas, new challenges, and new directions rather than keeping quiet or lamenting non-achievement of such organizations in fulfilling their stated goals. Encouragement and inspiration to old as well as up-coming organizations devoted to S & T popularization, and science activists would go a long way leading to national regeneration. It is then that our 'national reactor' will attain criticality.

(January 2002)

Scientific Laws and Society

"Give him a push, otherwise he cannot overcome his inertia!" "Once he gains some momentum he will be on his own!" "Do not hit him, he will hit back!" "Today's world has become so competitive that only the best can survive!" "Not all can do every kind of job, only certain type of people can do certain types of job!" "Unless one puts in a conscious effort, things can only deteriorate!" How often we hear such phrases! Indeed, these and many other phrases employed by us in everyday conversation originate from our experiences in different walks of life. What is more, we rarely come across any exception to these statements in the living world. We accept them as "laws" that govern human behaviour and hence society.

It is during our formal study of science that we become familiar with the laws that govern the natural phenomena. In due course, we realise that the laws of science do find parallels in fields other than science as well - be it in a social context or inter-personal behaviour. At a particular point of time, we feel convinced about the universal nature of the scientific laws and their applicability to almost any field of human activity. We are led to believe that our experiences in life - good or bad - were indeed manifestations of these laws.

As a result, we try to interpret almost every social phenomenon in terms of these "universal" laws. In due course, we tend to develop a faith that these are the laws that are fundamental to understand human nature. Surely, we marvel at the applicability of Newton's laws of motion to human behaviour when we talk about a push to overcome mental inertia which refers to the Newton's first law of motion. The tendency to react either physically or through angry words when hurt by someone is a manifestation of the Newton's third law of motion. When we say that only the best can survive in today's world, we are obviously talking of Darwin's famous law of survival of the fittest. A certain job that requires only certain kind of people to accomplish obviously refers to the natural selection doctrine of Darwin again. Finally, the statement that one needs to put in conscious and continuous effort lest order and discipline might deteriorate is an expression of the second law of thermodynamics. Indeed, one can find many more examples of application of scientific laws in fields other than science.

It is, however, necessary to exercise sufficient caution while applying the laws of science in the social context. Occurrence of an event in society is a result of several complex phenomena taking place simultaneously, or in quick succession. A social event is thus a sum total effect of different scientific laws operating within their domains either at the same time, or in quick succession. To understand or explain a social phenomenon or an event, it would be naive to take recourse to a particular scientific law in isolation, and ignore the rest.

Let us be more specific. Group clashes are often attributed to the Newton's third law of motion. However, if timely intervention is not made, there is every chance that the situation may deteriorate - the second law of thermodynamics making its ubiquitous presence felt.

Incidentally, there was a period in history spanning seventeenth and eighteenth centuries - the centuries in which Galileo and Newton lived - when the philosophers emphasized the use of reason as the best method of learning the truth, and relied heavily on the scientific method, with its emphasis on careful experimentation and observation. Indeed, this was called the Age of Reason. They attacked social injustice, superstition and ignorance. They blamed those who kept others in ignorance to maintain their vested interests and personal power. They believed that each person has a rational will which makes it possible to carry out plans, and has a capacity to reason. However, later on a great change occurred in people's outlook and the value system. They came to value feeling rather than the reason and prefer passion, individuality, and spontaneity to discipline, order and control.

Surely, to understand the complex social phenomena and how the scientific laws operate in the societal framework, it is today that we need the Age of Reason the most. Scientific knowledge and the laws of science should help us transform the society where peace and order prevail, and the quality of life improves. Let us refrain from tossing the names of great scientists to justify our actions or inactions. Let us not blame it on scientific laws for our misgivings!

(March 2002)

The Great Indian Arc of the Meridian*

More than two hundred years ago, on 10 April 1802 a daunting and audacious scientific endeavour began in our country. Called "The Great Indian Arc of the Meridian", it was the longest measurement of the Earth's surface ever to have been attempted. The idea was to map the entire Indian sub-continent and determine the exact curvature of the Earth. The intrepid band of the surveyors, initially under the leadership of Colonel William Lambton and after his death in 1823 under Sir George Everest took fifty years to traverse 2400 kilometres from Cape Comorin to Dehra Dun along the 78 0 East longitude. It is said that the inch perfect survey along the entire path took cost more lives than most contemporary wars, and involved equations more complex than any in the pre-computer age! It has been hailed as 'one of the most stupendous works in the history of science'. Through hill and jungle, flood and fever, the survey carried the Arc from the southern tip of the Indian subcontinent up into the snows of the Himalayas. William Lambton, an endearing genius, had conceived the idea; George Everest, an impossible disciplinarian, eventually completed it. Malaria wiped out whole survey parties; tigers and scorpions also took their toll. Besides the physical hardships, the technical difficulties were enormous. Their measuring instruments - theodolites, weighed half a ton, and observations had often to be conducted from make-shift platforms ninety feet above the ground or from mountain

* The Great Indian Arc of the Meridian was the longest measurement of the Earth's surface ever to have been attempted. This editorial provides an insight of the expedition, its importance and how India commemorated the centenary of the great expedition.

peaks enveloped in blizzard. A theodolite needed 12 men for carrying it around. Using these monstrous instruments, the survey covered the country with multiple strings of triangles in the north-south and east-west directions. Such surveys extensively employ application of trigonometry. Consequently, this gigantic project also came to be known as “The Great Trigonometric Survey”.

In 1843 Andrew Scott Waugh took charge of the project as Surveyor-General, and gave special attention to the Himalayan peaks. Because of clouds and haze, those peaks are only rarely seen from the lowlands, and until 1847 few measured sightings were achieved. Even after they were made, the results had to be laboriously analyzed by “computers” performing trigonometric calculations in the survey’s offices—of course human computers, not machines! In 1852, Waugh’s team succeeded in observing the highest peak in the world, its height being calculated at 29,002 feet (accepted height now is 29,035 feet or 8850 metres). From a distance of over 160 km, the peak was observed from six different stations, and “on no occasion had the observer suspected that he was viewing through his telescope the highest point on Earth.” Originally it was designated as Peak XV by the survey, but in 1856 Waugh named it after Sir George Everest, his predecessor in the office of Surveyor-General. Everest was the one who commissioned and first used those giant theodolites. They are on display in the Museum of the Survey of India in Dehra Dun. It was the Chief Computer, Radhanath Sickdhar (that is how he spelt his name!), who first realized that Peak XV was the world’s highest.

Now we can determine the position on Earth accurately using the global positioning system (GPS) of 24 satellites in precise orbits, constantly broadcasting their position. A small hand-held electronic instrument receives their signals and gives one's position quite accurately. A great deal of trigonometry is involved, but all calculations are done by a computer inside the gadget. The Great Arc made possible the mapping of the entire Indian subcontinent and the development of its roads, railways and telegraphs. The Great Trigonometric Survey can be considered as foundation of all the topographical surveys. More important still, by producing new values for the curvature of the Earth's surface, the Arc significantly advanced our knowledge of the exact shape of our planet

To commemorate the great expedition, the Survey of India has chalked out a year-long programme. The major events would include a Treasure Quest, Geo Quest Quiz, Great Arc Exhibition, Great Arc Documentary Film Series, and Great Arc Pictorial publications and so on. Indeed, this event could be utilized to generate an interest in mathematics and study of geography through a host of activities like students' projects in measuring heights and distances using method of triangulation and applications of principles of trigonometry, mapping local areas with the help of civil engineering departments of engineering colleges, field trips for familiarization with the local terrain – say, forest cover, water bodies, agricultural patterns, alongwith lectures and demonstrations, essay competitions, and so on. This is yet another opportunity, especially for the VIPNET clubs, to popularize science with activities built around the Great Arc of India. Indeed, it would be a fitting tribute to Lambton, Everest, Waugh, Sickdhar and countless others who helped define our country as we know today.

(April 2002)

Back with a Bang*

In December 2001, we celebrated the centenary of the wireless message sent by Guglielmo Marconi from England to New Foundland across the Atlantic. Indeed, that historic event marked the beginning of the process of transforming the world into what we today call a global village. Radio communication has since contributed in a number of ways to the growth and development of the society. There is no gainsaying the fact that over the decades, besides pushing the frontiers of science further ahead in various fields, communication technology has brought the people together separated through geographical and cultural barriers, and helped bring harmony in the society. This is especially true with a vast country like ours with a multiplicity of languages and cultural diversity.

The website of All India Radio mentions that the first radio programme in India was broadcast by the Radio Club of Bombay in June 1923. It was followed by the setting up of a Broadcasting Service that began broadcasting in India in July 1927 on an experimental basis at Bombay and Calcutta simultaneously under an agreement between Government of India and a private company called the Indian Broadcasting Company Ltd. When India became independent, the AIR network had only six Stations located at Delhi, Bombay, Calcutta, Madras, Lucknow and Tiruchirapalli with a total complement of 18 transmitters - six on the medium wave and the remaining on short wave.

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* On 12 December 1901 Guglielmo Marconi succeeded in sending radio signals across Atlantic. The editorial talks about the development in radio communication and its applications and its role in S&T communication.

Radio listening on medium wave was confined to urban limits of these cities. There were a mere 2,75,000 receiving sets at the time of Independence.

Development of semiconductor technology in the 1950s made radio as common an item as a wrist watch. A transistor radio set in one's hand was a familiar a sight in the 1960s and 1970s resembling mobile telephone of today! Now there are about 100 million estimated radio sets in the country, that is one radio set for about ten persons. The broadcast scenario has also drastically changed covering nearly cent per cent of country's population. But, radio was virtually pushed into the backyard as a result of the phenomenal growth of television, especially after the organization of Asian Games in 1982 in the country.

But, not quite. Despite the scores of satellite channels and direct-to-home television having been available in the 1990s, radio staged a come-back in the form of FM radio. FM services were then limited only to metros, and that too mainly for entertainment. The range was limited to 80-100 kilometres. It is only recently that Indira Gandhi National Open University has employed FM radio for educational purposes.

Now, a century after Marconi and half a century after Arthur C. Clarke (who first conceptualized a system of geo-synchronous satellites for global communication), the WorldSpace digital radio system is poised to revive the good old radio through the satellite medium. What is remarkable is the fact that it can cover the remotest and the most interior parts of a vast country like India. It is powered by three geo-synchronous satellites for digital radio communication spaced at 1200 apart. Indeed, it is a worldwide satellite digital audio system and also a multimedia system that uses these communication satellites to deliver signals directly into home to portable hand-held receivers. In effect, it is a direct-to-home radio. Live access to news, educational broadcasts, and entertainment from all around the world through its unique global relay capability are the remarkable features of this system. Since the broadcast is digital, it is possible to download the data files into a personal computer. It is even possible to transmit and receive slides / visuals, store them in a personal computer, and synchronize with the audio broadcast for a full fledged lecture-cum-demonstration. Further it is possible also to access selected websites on the internet.

Use of radio for science and technology communication, however, is relatively a new phenomenon. 13 - part radio serial on Method of Science in 14 Indian languages in 1989, and 144 -part radio serial on Human Evolution broadcast in 18 Indian languages simultaneously by all stations of All India Radio during 1991–1994 were true landmarks in the history of science and technology popularization in the country. Vigyan Prasar is putting in efforts to utilize the WorldSpace satellite digital radio system for science and technology popularization in the country in association with WorldSpace. Vigyan Prasar hopes to connect the VIPNET science clubs spread throughout the country, through the WorkdSpace satellite radio. Several of them are situated in the far-flung areas of the country. In the days to come, Vigyan Prasar plans to extensively utilize the new powerful technology of satellite radio communication for science and technology popularization, for education on and management of natural disasters and so on, along with other established technologies. Although a satellite radio receiver is a relatively expensive affair today, costing seven to twelve thousand rupees, in the days to come its cost is likely to come down drastically – as is the case with every new technology. Only a few years ago, all radios used to have only AM, now almost all radios come with built-in AM and FM. Within a foreseeable future, radios will include a satellite channel in addition to AM and FM. Indeed, radio is back with a bang!

(May 2002)

Not the end of the road

Central Board for Secondary Education results for class XII were declared on 25 May 2002. Within a week of declaration of results, six teenagers committed suicide in Delhi. One observes this pattern almost every year after the declaration of CBSE results. Why does it repeat so regularly? What prompts these promising youngsters to take this extreme step? Surely, there cannot be one single reason, but a combination of reasons. Children, and parents, perceive the Board examination as the examination of their life. They, however, fail to realize that it is only one of the many examinations that would eventually shape their lives – it's not the end of the road. Then, what is it that drives them to the point of no return? Is it the lethal combination of parental pressure and ambition? Is it growing competition? Or, is it the uncertainty about the future?

It is ingrained in the minds of children from the very beginning that only doctors, engineers, or professionals like MBAs count. A majority of children – and parents - do not even know that there are several other avenues and opportunities. May be this is one reason we have lakhs of children taking entrance tests for admission to medical and engineering courses every year with exponentially increasing numbers. Indeed, Arts and Science courses are looked upon as uncertain alternatives. This is why the idea of a career in these fields is rarely entertained by majority of the people. Unfortunately, it is ignorance among the parents and the society regarding opportunities in other fields that gives rise to this unfortunate scenario.

Surely, a majority of children fall within the middle part of the spectrum – termed 'average' as regards their academic achievement. It is likely that many of them may have a natural flair for fine arts, performing arts, science or literature. Every individual has a definite slot in the society where he/she snugly fits in. However, rarely they are allowed to pursue their own interests. Their interests, desires and liking are systematically suppressed. An effort is made to fix a square peg in a round hole. Unrealistic expectations from parents, schools and society put a tremendous pressure on them. Only if they are allowed to set realistic goals and blossom in a natural way, stress and tension could be considerably alleviated. Alongwith realistic goals, they need to be taught the need and value for hard work as well. This would help fight stress and depression effectively.

According to a psychiatrist, examinations or results could just be a trigger to a long term problem. The pressure of scoring high marks, parental ambition, and guilt of failing to do well convinces the youth that the only way out is suicide. Let us not thrust our ambitions on our children, and let us not make them feel guilty if they do not score well in the examinations. To begin with, it is imperative that we try to ascertain the child's natural interests and then help him/her identify a suitable career. This should help a child overcome inflexible and narrow vision of success. After all, a successful career implies that an individual puts in his/her best efforts in the chosen field, enjoys doing what he/she does, and excels in it. We also need to develop a support system with elders and friends. They should play a positive role in brushing aside a sense of despondency that is found among the suicide-prone. This would help them prepare in the event of a bad result. Further, it is desirable that the child's teacher in the school is able to communicate with him / her and help find out hidden worries and doubts. Regular counselling in a school also would play a positive role in curbing any violent tendencies.

At any point of time, one finds that more opportunities exist in one particular field than the rest. Remember the days, in early seventies, when admission to science courses used to be so tough? This was when career with the Atomic Energy programme of the country was considered highly prestigious. Also, mid-seventies, when there was a stampede for commerce courses following expansion of banks especially in the rural areas? Later on, it was non-conventional energy sources, environment, and telecommunication. In the nineties, it was information technology, and of late, it has been biotechnology. However, it is important to remember that jobs in any particular field are limited, even if that happens to be the field of one's choice. Surely, Government, or for that matter, private establishments cannot promise or provide jobs for all.

Where are the avenues and opportunities, then? Let us help our children find an appropriate slot for themselves, and refrain from imposing our ambitions on them. Let us help them grow in an environment where they can make their own choices, and pursue their own interests. They are sure to find sufficient avenues and opportunities to choose a career most suited to them. Our children then will not reach a point of no return.

(June 2002)

Keeping Droughts at Bay

India was extremely lucky to enjoy a series of good rainfall since 1989 during the south-west monsoon season every year. This has been the third long spell of normal or excess monsoon rainfall years in the past hundred years, the earlier two spells being in 1921-1940 and 1952-1964. For the country as a whole, the rainfall for the south-west monsoon for this year was expected to be normal according to the predictions of the India Meteorological Department. However, the rainfall has been too late and too little in most parts of the country despite the monsoon season nearing the end. Indeed, continuing dry spell in twelve States is a matter of grave concern. Our country has not experienced a drought as severe and as widespread in last twelve years. Surely, the worst impact has been on the agriculture. Kharif crop has been ruined in most of the affected States. We have already started experiencing power blackouts and water scarcity. Thanks to the plenty of food-grain stocks, it may be possible to tide over the situation till the next monsoon season.

Why did the monsoon fail us this time? Why did the prediction of good rainfall during the present season go wrong? One could attribute the failure of monsoon to a variety of unfavourable factors that may include, sea surface temperatures and pressures, correlation between the warm ocean currents off the south American coast and India called El Nino, snow cover, prevailing atmospheric conditions, global warming and so on. Further, the predictions are based on a mathematical model which needs continuous improvement in view of the new data and better understanding of the weather phenomena. Indeed, even after years of effort and experience, we still have not fully understood the strange behaviour of monsoon. Hence, we need to take monsoon predictions with a pinch of salt and not blame the weatherman should the rain-gods fail us.

Surely, droughts are nothing new to us. It has been a frequent and a natural phenomenon and follows a cyclical pattern. In last fifty years, we have experienced fourteen major droughts, the one in 1987 being the most severe that affected nearly half the land of our country. Then, how is it that after a bonanza of thirteen consecutive normal monsoons, the failure of monsoon this year has suddenly caught us unawares? Indeed, drought, or no drought, we need to manage our water resources efficiently, if we do not want the monsoon showers to make or break our fortunes.

There is no gainsaying the fact that unless we learn to "manage" a drought, it could become synonymous with the visions of parched earth, cracks in cultivable lands, unemployment, thirst, hunger and death. Anil Aggarwal always maintained that the entire nation could be made drought free through community rain water harvesting. His vision has become a reality in parts of Rajasthan, thanks to the commitment and foresight of Dr. Rajendra Singh and his team Tarun Bharat Sangh, who were instrumental in mobilizing communities to rejuvenate their own water resources. The traditional water harvesting structures built by the villagers under his guidance have changed the face of Rajasthan's Alwar and neighbouring districts of Jaipur, Sawai Madhopur and Karoli making them drought free. River Ruparel started flowing perennially after three decades. Indeed, it is among the 5 rivers of Alwar that has seen life after death. We have yet another success story in Maharashtra at Ralegaon Siddhi where the efforts on watershed management of Anna Hazare have helped a dry region become green through community participation and existing Government schemes. Why can't we follow the path shown by Rajendra Singh and Anna Hazare in other parts of the country as well?

Good water management can help create sufficient reservoirs to be used in the times of crisis. A case in point is the example set by the Rashtrapati Bhavan in rainwater harvesting to meet its water requirements. With a rain water system in place, its annual water requirement totalling 730 million litres is easily met. Regular workshops and training programmes to educate and apprise people on how to harvest rainwater would go a long way in tackling scarcity of water. A campaign to create awareness and provide practical information on rainwater harvesting needs to reach out to co-operative group housing societies and residential colonies, especially in the metros. Such programmes have largely remained a non-starter till now. It could now gain momentum. Let us begin right away.

The immediate task in drought affected areas is to ensure the availability of food and drinking water to both human and animal population. This is so because in many parts of the country, livestock and livelihood are intimately related. Professor M. S. Swaminathan even visualises establishment of Community Food Banks and Community Water Banks by the Government and operated by the self-help groups. He also suggests an integrated agricultural rescue package consisting of crop life-saving techniques, contingency planning, alternative cropping systems, and compensatory production programmes in areas where there is enough soil moisture. This would help in reducing the aggregate fall in agricultural production.

Government has already embarked upon the programmes such as food for work and employment for drought victims. It is this time that socially and ecologically relevant programmes could be initiated, say, construction of check-dams, digging farm ponds in rural areas where rain water could be stored and utilized for irrigation, deepening of existing ponds and lakes and so on. It is imperative to help people understand their own role and responsibility in mitigating drought, and equip them with necessary information, skills and training to keep drought at bay. It is raining opportunities for the science communicators and voluntary agencies to take up this challenge. This way we would have enough water the year round, and not just when it rains.

(August 2002)

Surviving New Drugs

According to a recent newspaper report, the drug nimesulide commonly prescribed for fever is found to have serious side-effects, and may cause complications in the liver, especially in children. Earlier this year, it was withdrawn by its innovator, Boehringer, from Spain and Finland. It is interesting that the drug was never licenced for use in Canada, the United States, Britain and Australia. However, it has been aggressively promoted in India for fever and pain relief. The report further states that while most doctors here insist that there is no need to press the panic button yet , they also admit that they know little about it. This is due to the fact that most studies on the drug are sponsored by the pharmaceutical companies themselves! A child specialist believes that one child that came to his clinic with acute liver toxicity and subsequently died could have suffered a reaction from the drug. However, this could not be established as a scientific fact as liver biopsy could not be done. He insists that the drug should be put through intensive scrutiny. Following a European Union warning, now a review has been ordered by the Drug Controller of India to ascertain its side-effects and risks.

Indeed, this is not the first time that an obsolete or a potentially harmful drug has been dumped on us. Yet another prominent example is analgin which could adversely affect blood pressure, kidneys and the liver, or cause allergic reactions. Then, how is it that these, drugs continue to be prescribed and freely available in the market? Indeed, this is a result of the aggressive promotion and marketing strategies of the pharmaceutical companies. Invariably, each company would quote a study to support its claim to prove superiority of the drug manufactured or promoted by it over its rivals. In the process quite a bit of disinformation is spread, doctors begin to prescribe the drug, and gradually it may even become available over the counter at any pharmacy though it is not allowed.

Quite often we are led to believe that it is quite safe to take a certain drug in case of specific symptoms. We insist on such a drug at a pharmacy. It could be nimesulide, analgin or even an antibiotic. Despite the fact that none of these drugs is allowed to be sold over the counter, that is, without the prescription of a medical practitioner we still insist on having it. Many a time, the pharmacist also happily obliges without bothering to tell us about its side-effects, if any. By resorting to self-medication, and with the help of the willing pharmacist, are we not compounding the problem further benefiting the pharmaceutical companies pushing obsolete or harmful drugs on us?

Let us not be taken in by the advertisements of medical or cosmetic quick fixes in the newspapers or other media. No one knows about the origin or efficacy of these quick fixes. There are hair raising advertisements to cure baldness, to remove dark circles under the eyes, for immediate relief from cold and headache. There are even drugs sold over the counter which ostensibly protect the user from a number of life risk conditions like stress, diabetes, cholesterols and hypertension! Let alone drugs, even medical procedures which could be potentially harmful are pushed through advertisements. A case in point is the beauty technologies so vigorously marketed in our country. Slimming technology is yet another example.

Indeed, it is vital that patients receive adequate information to enable them to use medicines safely and responsibly and to prevent and reduce the unnecessary use of medicines and the associated risks. No doubt, this is the joint responsibility of manufacturers, general practitioners and pharmacists. Information on correct dosage, contra-indications and side-effects should be displayed on the packaging and on the legally required patient information leaflet, in a language that is understood easily by the patient. Consumer organizations, general practitioners, pharmacists, Government and the non-government organizations need to work together and co-ordinate the flow of information from various sources in order to improve the public information. The World Health Organization publishes fairly accurate data on drug safety. It should be made easily accessible for the purpose. This would go a long way in strict enforcement of the law against the erring pharmaceutical companies.

There is no gainsaying the fact that we need to work out a strategy to protect ourselves from the hazards of obsolete and potentially harmful drugs being dumped on us. In addition, the public needs to be informed and educated about the risks associated with self-medication and falling prey to the misleading advertisements that seek to push drugs and questionable medical procedures. Educating the public on these issues will also help curb mushrooming of spurious drug industry to a great extent. Surely, this forms an integral part of what we call scientific literacy. The onus is on science communicators to take the initiative. Where do we begin? Please do write to us.

(October 2002)

Retain Traditions Change Attitudes

Diwali - the festival of lights represents the return of the legendary king Rama to his kingdom, Ayodhya. The festival brings with it the spirit of joy and happiness. It also brings with it tonnes of pollution caused by fire-crackers and deafening noise. Surely, the objective should be to have Diwali as a glowing and lightened festival of the year - not a noisy, disturbing, and a polluting event that may even cause serious accidents at times. In the Capital this year, pollution levels were marginally lower than those recorded last year. Apparently, oxides of nitrogen levels showed a marginal decrease compared to the previous year, while levels of sulphur dioxide remained more or less the same, but within permissible limits. A good sign indeed! However, the pollutants in the air, that is, the suspended particulate matter, remained five to eight times higher than the permissible limits (though somewhat less than the previous year!). As regards the noise levels, the peak was about 90 decibels (dB) as compared to 100 dB last year. The noise continued well past midnight, despite the Supreme Court order prohibiting bursting of crackers between 6 pm and 10 pm. Surely, all this made Diwali a festival of noise and pollution.

The higher level of suspended particles due to bursting of crackers during Diwali causes eye, throat and nose problems. Although many of us do not feel the immediate impact, these problems could develop into serious health hazards. Exposure to suspended particulate matter to the level of 100 parts per million (ppm) results in headache and reduced mental acuity. The effects are more pronounced in people with heart, lung or central nervous system diseases.

Indeed, for millions of those suffering from asthma, Diwali is not a festival of light and gaiety, but that of smoke, coughing and wheezing. They need to hold on to their inhalers which can help them breathe easier! A typical fire-cracker may contain 75 per cent potassium nitrate, 15 per cent carbon and 10 per cent sulphur. Potassium nitrate is a strong oxidizing agent, and when it burns along with carbon and sulphur, it releases noxious gases such as carbon dioxide, sulphur dioxide, and oxides of nitrogen. Oxides of sulphur, phosphorus and nitrogen are corrosive and highly acidic. These irritate the delicate linings of the airways that carry oxygen to the lungs and lead to asthma attacks. Sulphur dioxide is readily soluble and dissolves in the larger airways of the respiratory system and at higher levels, can cause severe contraction restricting the breathing process. Nitrogen dioxide is less soluble and so penetrates to the smaller airways and into the lungs and hence can cause respiratory allergies like asthma. Bursting fire-crackers in small lanes and passages creates what is known as the valley effect that creates big pockets of polluted air causing difficulty in breathing. Crackers like anar, wire and rockets which burn for a longer time cause more pollution. Indeed, the number of asthma and bronchitis cases shoots up significantly during Diwali days.

When the noise level increases, it results in restlessness, anger, impulsive behaviour, and even over reaction to many situations. Most crackers used have more than 80 dB noise level that can cause temporary hearing loss, according to medical practitioners. It could even cause high blood pressure, heart attack and sleep disturbances. Normal decibel level for humans is 60 dB. It would be worth noting that an increase of 10 dB signifies double the noise level. In particular, children, pregnant women, and those suffering from respiratory problems suffer the most due to excessive noise.

Even the trees and plants do not escape the fury of pollutants during Diwali. Trees and plants are covered with a layer of sulphur dust and suspended particulate matter. This blocks the stomata, or the pores on the leaves, obstructing the process of photosynthesis. This implies that the trees are prevented from releasing oxygen and moisture into the air. Even the birds' nests are not spared.

No doubt, school children have played an important role by organizing "say no to fire-crackers" campaigns and rallies to sensitize the people on the need and virtues of celebrating a peaceful Diwali. According to newspaper reports, children might have said a loud "No" to crackers, but not the adults - especially the neo-rich and the compulsive rebels, who defied the "say no to firecrackers" campaign. True, there was a slight decline in the air pollution levels compared to last year in Delhi, but the noise levels were higher at several places, in particular, in the posh colonies of the Capital. Dileep Biswas, Chairman, Central Pollution Control Board, remarked that the children seemed to be reconciled to the idea of a Diwali without crackers, but the adults are not! No doubt, it is imperative that our focus should now shift to the compulsive adults, and not just children alone.

The darker side of the festival of lights also manifested itself in its worst form this year. Eight teenagers died in an explosion in a fire-cracker unit in Tamil Nadu's Villupuram district on the eve of Diwali. There must have been dark in the homes of those children, who perished trying to bring joy and smiles to the faces of countless others. Are we not guilty of abetting a crime as heinous as child labour when we purchase firecrackers? No doubt, manufacturers of fire-crackers are even guiltier. Delhi's school children have set an example by not buying firecrackers made with child labour. But this cannot put an end to it. It may continue in silk factories or in factories producing beautiful glassware.

There is no gainsaying the fact that parents who earn reasonably well, may not be compelled to send their children to a cracker factory, but would educate them. How shall we bring smiles to their faces? The day we shall realize this dream, limiting health and environmental hazards at the same time, that we shall be able to restore Diwali to its pristine glory. We may retain the traditions, but change attitudes in the larger interests. Let us resolve to celebrate Diwali by lighting lamps, not by bursting crackers.

(November 2002)

Why Popular Science Writing is So Unpopular

How is it that despite continuous efforts and sustained encouragement from several Government and non-Government organizations over the years, the number of popular science writers has remained minuscule? Does it imply that there is little demand for it? Or is it that the popular science writing today, especially in the regional languages, has not been able to meet the expectations of the general public? Why does the younger crop of scientists shy away from taking up popular scientific writing as a career? Why it is that translation of an article, especially from English to a regional language, more often than not, looks like Greek and Latin?

Well, it was in this backdrop that a seminar was organized in Delhi jointly by Institution of Electronics and Telecommunication Engineers (IETE) and Commission for Scientific and Technical Terminology (CSTT) in Delhi on December 5-6, 2002, sponsored by the Ministry of Information Technology (MIT) on the theme 'Making scientific / technical writing in Hindi interesting'. The topics ranged from what is a popular scientific article and how to make it interesting, to the difficulties faced while searching for acceptable scientific / technical terminology – both while writing an original article to translating an article from another language into Hindi.

To begin with, let us realize that there is a sizeable demand for popular science literature, especially among the children – both in urban as well rural areas. This could be judged from the speed with which popular science books brought out by Vigyan Prasar and other publishers get sold out in book exhibitions in different parts of the country. We do not need to create a demand, it already exists.

The basic question is - what ails the popular science writing in our country? We continue to think in English but try to popularize science in local languages! Often we first write an article in English and then translate it in the local language! In the process, it no longer remains popular! Until we begin to think in the local language, write in the local language (Matri Bhasha, as was pointed out in the January 2002 issue of Dream 2047) popular science writing will continue to be unpopular.

Indeed, it was through reading popular science literature that many great scientists were first introduced to the thrill and excitement of science. However, inspiring and igniting the young minds through popular science writing is yet to find a place as a career or profession in our country. It is true that as of today, popular science writing is not as lucrative as other professions, but it is a highly rewarding and a satisfying profession. It is only the mindset that needs to change. We do have examples wherein individuals have dedicated themselves fully to popular science writing and yet made a decent living and led a highly meaningful life. One example is that of the well known popular science writer Gunakar Muley.

In any case, one cannot but overemphasize the importance of translating scientific articles / books into local languages Equally important is to make available to our children and the general public the inspiring popular scientific articles / books by great science communicators from all over the world, say, George Gamow, Arthur C. Clarke, Carl Sagan, Isaac Asimov, Stephen Hawking etc. in the local languages. Alas! It is just not available. The hard fact is that we do not even have enough number of accomplished persons who can translate a popular scientific article into a regional language which can be understood with relative ease by a lay person. Translation of scientific articles from English into Hindi or any other regional language that is palatable, itself could be a lucrative profession. CSTT has been putting in efforts to develop scientific/technical terminologies for various Indian languages, but it is likely that many of the terms may not even be acceptable in the local language. When we shall begin to think and write in the local language, the acceptable terminology would automatically develop. We may even need translation bureaus for translation of articles from one Indian language into another.

J.B.S. Haldane once said that writing a popular science article is like organic chemical synthesis. The method to be adopted depends on the product required, the raw material and the apparatus available. Further, since the apparatus is the brain, the method may vary from person to person. Undoubtedly, it is a difficult task, and one cannot expect to be successful at the first attempt. It is an art to be developed and cultivated. What is important is the fact that the article communicates to the reader - which in all likelihood is the lay public - the essence of the subject matter in a friendly manner without sacrificing the scientific accuracy. Further, it should describe a concept or a phenomenon through everyday experience leading from known to the unknown. It is assumed here that the article is written in a language the reader understands.

Popular science writing must aim at helping people organize, analyze, and help apply information to arrive at a solution. This may even include addressing issues that may directly affect their lives, say, CNG, transgenic crops and so on. It is also worthwhile showing continuity of human thought by giving references / examples from other spheres of human activity as well, social or economic. Further, it is necessary to emphasize unity of human knowledge and endeavour, at their best. It is then that popular science writing would truly become ‘popular’. It is gratifying to note that a few well known scientists in our country have taken upon themselves this task and in the process inspired many to follow the suit.

(December 2002)

A Blueprint of Life*

Gregor Johann Mendel made two astonishing discoveries in the middle of the 19th century when he planted peas to investigate the rules of heredity. He discovered that many characteristics are inherited in an all-or-nothing way. A plant is either tall or short, its seeds either smooth or wrinkled. Second, that cross-breeding can cause a characteristic to disappear. When tall are crossed with short, one gets only tall offspring. But, when those tall offspring are crossed with each other, the grand-seedlings of the original plant will include short individuals too, the ratio of tall to short being 3:1. Mendel showed that the information an individual inherits from its parents and uses to construct itself comes in discrete packets which he called "factors" and that those "factors" can be passed in tact from generation to generation – even if they sometimes sit silent and unexpressed in some of the intermediate generations.

Today, Mendel's "factors" are known as genes. Mendel showed that his "factors" (genes), must be present in two copies per individual, but that only one copy is present in the egg and sperm. Since each new individual is formed from the union of an egg and a sperm, the number of each gene is restored to two when egg and sperm unite. Because of its peculiar structure, DNA, the chemical of which they are composed, can both encode vast quantities of information and replicate what it encodes. The sequencing machines in dozens of laboratories all over the world are busy decoding that information for man, other creatures, and plants.

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* Year 2003 marks 50 years of discovery of double helix and 25 years of *in-vitro* fertilization (IVF).

During the early twentieth century, researchers tried to find the physical place within cells where heredity begins. They focused on chromosomes, slender strands of material in the nucleus of the cell. It was realized that the chromosome was likely to be the physical place in the cell that contained the genes. This idea was confirmed when it was shown in 1927 that X rays could damage the chromosomes of flies and that this damage affected their genes. That X rays could cause mutations (or changes) in genes suggested that the genes could be altered. In 1944, Oswald Avery, Colin MacLeod, and Maclyn McCarty showed that genetic information was contained in the chemical DNA (deoxyribonucleic acid). They took DNA from a pneumonia-causing bacterium and transferred it into a harmless kind of the same family of bacterium. This action transformed the harmless kind into the deadly kind of the bacterium — showing that only DNA had the information needed to make the bacteria harmful. This conclusively proved that DNA could convert into code all the instructions for life. Indeed, it was a blueprint of life.

Perhaps the most important discovery in the field of genetics was the structure of DNA. Exactly fifty years ago, James Watson, an American biologist, then only 24, and Francis Crick, an English physicist, first proposed the now well-known double helix in 1953. The double helix structure also suggested a solution to an old, perplexing problem: how is DNA copied each time a cell divides? The answer was obvious looking at the helix: each of the two strands of the helix paired with one other: adenine (A) with thiamine (T), and guanine (G) with cytosine (C). One strand was the perfect counterpart of the other, a chemical mirror image. So, if a cell had just one strand, it could always "figure out" what the other strand should be. This immediately explained how DNA could be copied: either strand could be copied and the same information would result.

Scientists now knew that DNA was the molecule of heredity. They also knew that there was a code made up of the chemicals A, T, G, and C in a special sequence within the DNA. They had to crack the code. This was accomplished in the early 1960s by several scientists, including Marshall Nirenburg and Har Gobind Khorana. However, it was still impossible to isolate a gene or to read all of a gene's A, T, G, and C chemicals in the laboratory. Stanley Cohen and Herbert Boyer developed a technique for transferring a single gene from one organism to another, also called genetic engineering. Their discovery allowed scientists to isolate genes from any organism and to make large amounts of that gene for analysis. Walter Gilbert and Frederick Sanger devised methods to "sequence" DNA. This implies identifying in correct order the As, Ts, Gs, and Cs that make up DNA. The third invention was the polymerase chain reaction devised in 1985 by Kary Mullis that allowed extremely small amounts of DNA to be faithfully reproduced in the test tube. Indeed, these developments formed the foundation of the Human Genome Project.

Eventually, in early 2001, we had the first global view of the genomic landscape of human beings. The most crucial discovery was that the difference in different genomes between different races is minuscule, only 0.1 per cent! That is, 99.9 per cent of human beings have the same DNA! The other surprise was that the number of human genes is only about 30,000 as against the initial estimate of 100,000. In addition, the belief that one gene is responsible for one protein no longer holds. It is now thought that the average human gene produces three different proteins. This work is expected to enable scientists and doctors to understand the genes that control all diseases to which the human race is prone, and hopefully develop new therapies to treat and predict diseases. The introduction of transgenic crops and foods into the existing food production system has also generated a number of questions about possible negative consequences. Indeed, we have come a long way since the discovery of the double helix structure of DNA in last fifty years.

Many discoveries and inventions have shaped the 20th century, but, often it is argued that electricity was the most important of them. As the 19th century is known as steam century, the 20th was the electric one. It is said that the 21st century may be the DNA century! Besides fifty years of discovery of the double helix structure of DNA, the year 2003 also marks twenty five years of in-vitro-fertilization (IVF).

(February 2003)

The Road to Space*

It is said that road to success is littered with ups and downs, and the road to space is littered with debris. Indeed, every nation venturing out in space has had its share of calamities. There have been some 59 failed space missions since 1990 involving launch vehicles and satellites, including two of India. However, the loss is much too poignant when the precious human lives are lost. In the 41 year history of the manned space flight, 21 lives have been lost. Three astronauts of Apollo 1 crew were killed during launch pad fire in 1967. A Soyuz 1 cosmonaut was killed on landing after 26-hour flight only a few months later. The Soyuz 11 crew of three cosmonauts was found dead in 1971 at the end of the mission. The entire crew of seven astronauts of the space shuttle Challenger was killed when it exploded barely a minute after the launch in 1986. And on 1 February, 2003 the crew of seven astronauts of the space shuttle Columbia was lost when it exploded on re-entry when they were only sixteen minutes from home - so near and yet so far! One of them was Kalpana Chawla, who dreamed stars, but did not return home. Like Seneca, she thought "the whole Universe is my native land."

Indeed, the space shuttle is the most complex space vehicle built till date. It blasts off like a rocket, flies like an aircraft, and lands like a glider. It is different from the space vehicles like Saturn rockets used for Apollo missions, Ariane,

* On 1 February 2003, while returning after a successful mission, the space shuttle Columbia exploded during re-entry to the Earth, killing all seven crew members. One of them was Kalpana Chawla.

PSLV or GSLV, whose spent stages fall into the sea after blast-off and cannot be used again. On the other hand, the shuttle can fly hundreds of times. This is why it is called the Space Transport System (STS).

The STS-107, Columbia, blew up as it returned to Earth after a successful mission. Incidentally, it was the oldest of space shuttles flying its maiden mission in 1981 and affectionately nicknamed The Old Gray Lady. Its crew included, among others, an Afro-Asian, an Israeli, and the Haryana-born Kalpana Chawla. Her early dreams of flight were inspired by JRD Tata. Its theme was Space Research and You. It carried some 80 experiments designed to help us learn how to tackle practical, everyday problems on Earth for common benefit. Some of the experiments included the study of change in metabolism, hormone levels, and the reaction of the human body in microgravity, how heart and lungs function in space, flow of blood and body fluids in weightlessness, and macromolecular protein crystal growth. An interesting experiment Kalpana did was to examine the use of fine water mists to extinguish fire. The losses include the extremely valuable data from these scientific experiments. Indeed, Columbia crew had successfully completed its task, and that is why its tragic end has been even more poignant.

Although it is still not clear what caused Columbia's fiery descent, but it is likely that the heat shield was breached on the left wing. It is even possible that impact by space debris could have damaged the heat shield tiles. Was it an inherent structural defect? Or was it due to the heat resistant tiles having suffered damage during take-off? Until the exact cause of the accident is determined, the further STS missions have been suspended, and a hard look at the other three shuttles, namely, Endeavour, Atlantis and Discovery has become necessary. The suspension of the shuttle flights has adversely affected the half-constructed International Space

Station (ISS) that has been orbiting the Earth since 1998, a project in which as many as 16 countries are involved. This would imply delays in completing the structure. Of course, the three astronauts aboard ISS do have adequate supplies for a few months. They also have an escape vehicle to get away in case of emergency. Further, despite Columbia disaster, Russia has gone ahead with its scheduled launch of an unmanned re-supply vessel to ISS.

Incidentally, Columbia was Kalpana's home on her earlier space odyssey as well in 1997 (STS-87). The mission then focused on experiments designed to study how the weightless environment of space affects various physical processes, and on observations of the Sun's outer atmospheric layers. Her specific job then was to release the Spartan satellite to study the Sun. She was the first woman to earn an aeronautical degree Punjab Engineering College 1982, Master of science in aerospace engineering from University of Texas, 1984, and Doctorate of philosophy in aerospace engineering from University of Colorado, 1988. Indeed, it was against all odds that she was chosen as an astronaut in 1994.

Let us realize that all explorations are perilous – whether in space or on Earth. Kalpana and her colleagues worked in peace and harmony several hundred kilometers away from the Earth. Their goal was universal peace and progress of humankind. We need to embark on their path on the ground beneath us as well, if we are to survive. This requires a dream, vision and courage. Kalpana said in an e-mail from Columbia to children of her former school in Karnal: "The path from dreams to success does exist. May you have the vision to find it, the courage to get on to it, and the perseverance to follow it. Wishing you great journey."

(March 2003)

At War with SARS*

Throughout history, epidemics have been responsible for a sizeable portion of the fatalities suffered by the world. As long as people lived in small groups, isolated from each other, such incidents were sporadic. But, as civilizations progressed, people began clustering into cities. As cities became crowded, they also became nesting places for water-borne, air-borne, insect-borne, and skin-to-skin infectious diseases that spurted out unchecked, and seemingly at will. Today, while some of the dreaded diseases have been either eradicated (say small pox) or effectively controlled (say polio or plague), diseases like malaria, influenza (also known as flu) and gastro-enteritis still continue to haunt us again and again with renewed resistance and severity every time they strike. A few diseases have spread to such an extent that lakhs of people die every year. For example, tuberculosis claims roughly 1500 people every day in India, that is, about half a million every year.

The worst epidemic in the twentieth century was probably caused by the influenza (flu) virus that now-a-days has relatively low chances of fatality if contracted. The worst case of this flu was in 1918 which started during the World War I in USA. It could be better described as pandemic—an infectious disease that affects many people over a large region or continent. Within a few months, most of the 1.5 million American soldiers who crossed the Atlantic to fight the war in Europe carried across the

* In 2003 SARS outbreak hit the world. The editorial provides insight into the epidemic where it started, its spread, damage and possible measures to control the pandemic.

flu virus and infected others when they joined the front line. Further, the microbe mutated as it spread adopting to new environments, and soon moved across Britain, Italy, Germany, France and Spain, and many other regions in Europe. In total around 20 million people were killed by the time the epidemic went into retreat.

We are now on the brink of yet another pandemic with symptoms which are extremely general and non-specific. For want of any specific symptoms, it is called Severe Acute Respiratory Syndrome (SARS), and is a new viral inflection. Like in pneumonia or flu, the illness usually begins with a high fever greater than 100.40 F, dry cough, shortness of breath or difficulty in breathing. Some people may get a headache, stiff or achy muscles, rash and diarrhea. High fever is accompanied by cough initially, respiratory distress may occur then, and finally the patient may go into an acute respiratory syndrome and may even die. If appears that close contact with someone who has SARS is necessary to contract the disease; namely when someone sick with SARS coughs or sneezes releasing droplets into the air and someone else breathes them in.

It seems it all started in the Guangdong Province of China with cases of atypical (unusual) pneumonia reported since 16 November, 2002. By the second week of April 2003, China has reported 1418 cases of SARS and 64 deaths, followed by Hong Kong with 1232 cases and 56 deaths. Till the time of writing this editorial (i.e. 15 April, 2003) SARS has spread to 24 countries in four continents with total number of cases being 3235 and 154 deaths. Research attention is increasingly focussing on the hitherto unrecognized coronavirus. Incidentally, coronaviruses are a group of viruses that a halo or crown-like (corona) appearance when viewed under a microscope. They are a common cause of mild to moderate upper-respiratory illness in humans and are associated with respiratory, gastro-intestinal, liver and neurological diseases in animals. They can survive in the environment up to as long as three hours. Viruses from the paramyxovirus and other families are also being considered as scientists cast the widest possible net in their search for the cause for SARS.

Indeed, hypotheses include a virus known to cause a disease in an animal host that has jumped the species barrier to infect humans, or a known human virus that has mutated to acquire properties that cause much more severe disease in humans. SARS being a disease caused by a virus, no antibiotics are effective. Hence patients with SARS are recommended the same treatment as that for atypical pneumonia of unknown cause. Medicines for fever and syrups for cough relief are recommended. Antiviral agents like ribavirin or oseltamivir, and even steroids have been tried, but, their, efficacy remains unproven. Most patients eventually recover from SARS, but about three to four per cent die. It is, therefore, important that the patients must be kept in segregated environments to prevent other people from being exposed to them.

Although the SARS virus has yet not found its way into India, how do we prevent its spill over? Well, probably the most cost effective prophylactic against SARS would be information sharing. Undoubtedly, information sharing is crucial to ward off the coming danger—whether for the health service authorities or the general public. Ignorance only aggravates panic and fear. It was because of ignorance, fear and lack of sharing of information that SARS migrated from Guandong to Hong Kong, Singapore, Thailand, Vietnam, Canada and other countries across the globe. Most countries with occurrence of SARS are dealing with it on a war footing. Besides WHO, Governments of several countries provide excellent and up-todate information on their websites about symptoms, precaution and preventive care of SARS. As of today, no Indian website (other than Vigyan Prasar) is providing detailed information on SARS. Well, let us not be caught unawares. Since the symptoms of SARS are extremely general or non-specific, it is possible that it is confused with other ailments. This is a risk which is much higher in countries such as India where levels of awareness are low, and where ordinary viral fevers with similar symptoms are prevalent. Indeed, we already have had a precedent. The first case of AIDS was detected in India in 1986. Thanks to the inadequate medical infrastructure and lack of information, AIDS infects some four million people in the country today.

SARS has already spread to North America, Europe and Australia. Some countries, including India, have started screening passengers coming by international flights, especially those coming from China, Singapore and Vietnam. But, just exactly where else and how quickly SARS would strike are questions one cannot answer. Countries like India with a lack of medical infrastructure and low levels of public awareness face the greatest risk from the disease that resembles ordinary fevers and which can spread on close contact. What is required is the knowledge and awareness about how it spreads and what people need to do to protect themselves. Needless to say, media need to be utilized to the fullest extent. In addition, seminars should be organized to spread awareness at every level, and discussion groups formed. Indeed, SARS is spreading with the speed of jetliners. Let us not be complacent. Let us be fully prepared lest we find ourselves at war with SARS.

(April 2003)

A Hard Way to Software

Not long ago, the term software only meant computer software. Now it includes all forms of audiovisual programmes – say, audio (including radio), video, films, slide shows, printed matter, and of course CD-ROMs and multimedia. The term has almost become a part of daily life – more so, if one happens to be a media person or a science communicator. When we talk of media – any media – we invariably talk of software and the quality of software. Embark upon a mass awareness campaign, development of an activity module for schools, a radio or a television serial, and the greatest challenge before the organizers and producers is to produce quality programmes - or software, which is relevant, interesting, meaningful and acceptable by the end users. Indeed it is a great challenge. If the software to be produced is for Science & Technology (S&T) communication, the challenge is even greater. Several agencies in the country today are engaged in producing software for S&T communication. All India Radio broadcasts at least one programme everyday on a scientific topic from all its stations, in addition to the ones on health and agriculture.

Several AIR stations with science cells broadcast three programmes per day. Doordarshan telecasts about two programmes every week on the national network, and all regional centres put together produce and telecast some 100 S&T programmes every year. UGC, CIET, and IGNOU have regular slots on Doordarshan. IGNOU even has its own network for FM radio and television with a twenty-four hour satellite TV channel. A few other Government / non-Government agencies too have hired regular slots on radio and television channels. However, with a population of a billion plus, eighteen major languages, varied needs of different geographical regions, and diversity of cultures, this is less than a drop in the ocean! How do we go about it then?

Given that the social and economic progress of a country depends on the application of S&T, it is imperative that due emphasis be given to dissemination of information on current issues / topics, and communicating to the people how closely their lives are entwined with S&T and scientific outlook. With growth of Information Technology coupled with significant increase in literacy and spread of education, expectations of the people also have gone up. To accelerate the process of development, Indian Space Research Organisation (ISRO) is planning to launch a satellite - Edusat - exclusively for education in which a channel would be dedicated to S&T. As a result, Edusat would indeed stand for Education, Science and Technology. Of late, Development Educational and Communication Unit (DECU) of ISRO has been organizing brain-storming workshops in different parts of the country to assess the needs of the people, the type of software to be produced for different target groups - or content development as it also called, and the ways and means to produce a large number of good quality programmes to continuously feed the science channel. More often than not, the discussions during these meetings centre on the production of “good” software. Normally there is consensus that despite we have wherewithal, technology, resources, and creative producers, what we still lack is the content. Why is it so?

The science channel for Edusat will require a variety of programmes to be developed for various sections of the society and age groups. In particular, at school level, the content for formal education may include topics in curriculum or enrichment material. The content development for the non-formal stream of science education is a much more daunting task. It may include topics like model rocketry, origami, astronomy, water, environmental issues, cropping patterns and so on. These topics could be simultaneously dealt with even for out-of-school students studying through alternative systems like National Open School or Sarva Shiksha Abhiyan. Even if some agency is not directly involved in production of S&T video programmes, it can still contribute to the production, say, in development of scripts, or can provide subject experts. A large number of resource persons for S&T popularization have come to the fore in last couple of decades. They could form a large pool of highly accomplished resource persons/ experts for content development.

Surely, we have adequate infrastructure in the country with facilities like TV studios, labs and workshops for R&D and production of software for S&T communication. Despite the fact that we have a number of AVRCs, EMRCs, SIETs and DDKs, how is it that the number of producers of "good" software on S&T is minuscule? A majority of producers today are not conversant with the techniques and requirements of production of software on S&T. No doubt, this issue would need to be resolved at the earliest. There is no gainsaying the fact that we need to embark upon a programme to "produce" good producers of software on S&T.

Once the topics/issues are decided upon through workshops at regional and national levels, the next step would be to invite the subject experts to develop the contents and prepare briefs / write-ups on individual topics. The briefs / write-ups could be given to the producers depending on their aptitude. The producer may modify the script to meet the specific demands to suit the production maintaining the accuracy of scientific information in the script. The demands for interactive programmes, say two way audio and one way video are quite specific and also require special skills on the part of the producer. It also needs a good deal of coordination with the studios where the talk back facility is provided. This being a relatively a new area, special attention would need to be provided for the purpose. Transmission with Edusat being digital, selected programmes / software could also be made available on CD-ROMs and disseminated to the schools.

Finally, it is important to realize that the format in which the software is to be produced depends on the content. It is the content that decides the format of a programme to be produced – say, dramatization, questions–answers, quickies, and so on. Further, it is imperative that information be combined with entertainment. This demands a good understanding of the subject matter on part of the producer, creativity and imagination. In addition, every programme to be produced should aim at triggering an interest in science alongwith inculcation of scientific attitude. Is it demanding too much? Perhaps yes. But, we do not have much of a choice but to attain the high professional standards combined with creativity and imagination if we hope to transform our country into a nation of scientifically thinking people. Otherwise, we shall always be playing the second fiddle. Indeed, it is a hard way to good software.

(May 2003)

Little Bumps under the Spreading Sky*

It is fifty years since man set foot on the Mount Everest, the highest peak in the world. How did the interest in the Himalayas develop in the modern times? It all began with a daunting and an audacious scientific endeavour two centuries ago in our country called "the Great Indian Arc of the Meridian". It was the longest measurement of the Earth's surface ever to have been attempted. The idea was to map the entire Indian sub-continent and determine the exact curvature of the Earth. William Lambton had conceived the idea, and after his death in 1823, George Everest (Surveyor General of India,1830-45) and his intrepid band of surveyors took 50 years to traverse 2400 kilometres from Cape Comorin to Dehradun along the 780 East longitude. In 1843, Andrew Scott Waugh took charge of the project, and gave special attention to the Himalayan peaks. In 1852, Waugh's team succeeded in observing the highest peak in the world. Its height was calculated at 29,002 feet (accepted height now is 29,035 feet or 8850 metres). It was Radhanath Sickdhar, the Chief "Computer" who realized that it was the world's highest. Waugh named it Mount Everest immortalizing his "illustrious master of accurate geographical research".

The realization that Mount Everest (Sagarmatha in Nepali and Chomolungma in Tibetan) as the highest peak in the world fired the imagination of the people the world over – only no one knew how to get there. Further, the early

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* On 29 May 1953, Edmond Hillary and Tenzing Norgay scaled the Mount Everest, the highest peak in the world. While commemorating 50 years of the event, the editorial provides a historical account on the journey so far to the highest peak.

climbers had to contend with the most primitive equipment. Nepal did not permit approaching the mountain from the south side until after the Second World War, and hence the only route to the summit was from the north side in Tibet. The first expedition to Mount Everest was in 1922 when Geoffrey Bruce and George Finch climbed to a record altitude of 8627 metres with rudimentary oxygen. In 1924, the mountain claimed the life of George Leigh- Mallory and Andrew Sandy Irvine who were climbing without oxygen (seventy five years later, on 1 May, 1999, Mallory's frozen corpse was found at a height of 8170 metres). Till the end of the Second World War, there were a few expeditions, however, none was successful. Climbers after the War came equipped with war-time technologies. After the war, Nepal opened its gates to the mountain offering the south-east ridge route. A Swiss team – consisting of Raymond Lambert and Tenzing Norgay - made it to 8598 metres.

Eventually, Edmond Percival Hillary and Tenzing Norgay reached the top on 29 May, 1953 via the south-east ridge route, equipped with oxygen and special nylon-weft suits which could withstand winds up to 100 kilometres an hour. Fifty years since they got there, some 1200 people have made it to the top. Appa Sherpa has made it 11 times - without supplemental oxygen. Another two have made it 10 times. Kushang Sherpa climbed the peak from all the four sides. The oldest to reach there was 70, the youngest 16. Even women have not lagged behind. Junko Tabei of Japan reached the peak on May 16, 1975.Then followed Bachendri Pal of India. Santosh Yadav climbed the peak twice. Handicapped men with artificial feet and even a blind man have reached the top. People have paraglided and skied down from there. The lure of the highest point in the world continues to draw hundreds soon after the winter season ends, despite the fact that 176 lives have been claimed by the mountain so far.

For Tenzing, it had been a long and weary road. Acting as a porter on Sir Eric Shipton's 1935 exploration of Everest, Tenzing became involved in more attempts to scale the peak than anyone else before him. In 1938, he climbed Everest to an altitude of 7,000 metres above mean sea level. In a 1952 attempt, he ascended to 8,600 metres. After Second World War, Tenzing Norgay became a "sardar" or supervisor of porters. He was both a "sardar" and a member of the British Everest Expedition in 1953. Although he spoke seven languages, he could never read or write! In contrast, Hillary read a book a day about adventures in his childhood. For many years he was a beekeeper. He was introduced to the Southern Alps of New Zealand since he was sixteen. He served the New Zealand Air Force in the Second World War. He was a participant in the 1951 and 1952 Everest expeditions. After the conquest of Everest, he trekked to the South Pole and up the river Ganga from the ocean to its source in the Himalayas. He served as the New Zealand High Commissioner to India for four years.

Over the past two decades, advances in the mountaineering equipments have made the climb much easier. Ice-axe is featherweight and made of titanium, the shoes are lightweight and do not freeze, oxygen cylinders that weigh only 3 kg, lighter and sturdier tents – everything has changed. Today's mountaineer has cutting edge technology with him. He has a satellite phone in one hand and is backed by detailed weather forecasts. Tenzing and Hillary carried some 30 kg. Today a mountaineer carries less than half that weight. What has this done to Mount Everest? Over the past few years, the traffic to the highest peak has gone up at an astonishing rate! On one remarkable day, 23 May 1991, 89 climbers reached the top! It has gradually been transformed into a tourist spot! Fiftieth anniversary has drawn record crowds this season. One can climb to the world's highest point by paying up to Rs. 30 lakhs! It is a big business. As a result, already enormous environmental degradation has been caused to the Everest. Global warming has added to the problems and the studies indicate that the entire Khumbu region faces long-term flood threats because of accelerated ice-melt. Excessive human activity only could make things worse.

Indeed, conquest of Everest was a turning point in history of exploration. It is a saga similar to stepping on the South Pole by Roald Amundsen (1911) and Robert F. Scott (1912), or on the North Pole by Admiral Robert Peary (1909), or the famous "small" step on the Moon by Neil Armstrong (1969). We climb Mount Everest because "it is there" and travel to the Moon also because "it is there". But, once we get there, it is our duty to preserve it.

Tenzing and Hillary's has been a saga of a well planned, steady progression up the mountain until there was nowhere higher left to climb. Tenzing narrated his view from the top of the world in these words: "… For the closer peaks – giants like Lhotse, Nuptse, and Makalu – you now had to look sharply downward to see their summits. And farther away, the whole sweep of the greatest range on Earth – even Kanchanjunga itself – seemed only like little bumps under the spreading sky". Indeed, all our endeavours - scientific or social - are like climbing up the Mount Everest. The higher we reach, the smaller shall our earlier achievements appear to be, and farther shall we see.

(June 2003)

A Jheel and a Lagoon

I recently read two inspiring success stories in the Survey of the Environment 2003. Not long ago, in Jadavpur, Kolkata, there was once a rubbish-infested, choked dump. Only a few decades ago, it had been a sprawling jheel (natural water body bigger than a pond)) with some 9,000 square metres of area, and was the hub of community activity. It had transformed into the dumping ground of the locality. Hyacinths choked the banks. Mosquitoes and the stench of garbage dumped made life miserable for the people living in the area. This stirred the conscience of a group of middle aged men who were born on the Jheel Road. Incidentally, the road got its name from the several jheels which were once upon a time closely intertwined with the life of the people in that area. They were gradually filled up and multi-storied structures came up on the 'reclaimed' land.

The group of these men took up the challenge, and thus began a saga in March 1999 to rejuvenate the dying jheel. Soon the Jheel Road Sangrakhyan Committee was formed with the local councillor as its president. The mobilization began in full steam and contributions from the office-goers and the residents began filling their kitty. Their priority was to remove the hyacinths asphyxiating the jheel and to pump out the polluted water. As the word spread, more and more locals and the environmental enthusiasts volunteered. Now there was a growing hill of water hyacinth on the jheel road that required 200 truckloads to clear the muck! The question was to raise the huge funds, labour and a fleet of trucks for the purpose. But, help came in from numerous quarters in terms of funds, manpower and the technical expertise. The committee successfully roped in eminent individuals, engineers, and people of all shades of political parties. Today, the clear waters of the jheel surrounded by the beautiful trees are a source of pride and inspiration for the local people. What is more, the members are aware that now they have to maintain and protect the jheel, and pay adequate attention to fish cultivation, aquatic life, immersion of idols and so on. Indeed, this is a saga of a group of people concerned about the need to conserve their immediate environment.

Here is yet another saga. The Chilika lagoon is situated along the East Coast of India in Orissa. A lagoon is a sheet of salt water separated from the open sea by a low sandbank, coral reef etc. Chilika is a unique assembly of marine, brackish and fresh water ecosystems. It shelters a number of endangered species and is a favorite resort for millions of migratory birds. Chilika sustains some one million people - fishermen and those who live on its catchment areas. However, for decades the lagoon had been facing tremendous pressure due to the change in the land-use pattern and construction of hydrological structures – say, dams on the major rivers draining into the Bay of Bengal. The net result was the loss of biodiversity and productivity that affected the livelihood of local community. This is what prompted the Government of Orissa to establish Chilika Development Authority in 1993.

The major problems of the Chilika lagoon were siltation, fall in salinity due to the blockage of the channel that allowed the entry of sea water (as a result of siltation), decline in fish yield, proliferation of fresh water weeds, poor discharge of flood waters leading to water logging in the peripheral crop land, and the way sea water entered into the lagoon and moved back into the sea.

The most important feature of the plan was the village level meetings to consult the people - the stakeholders - for their suggestions and recommendations. It also extensively involved the scientific and professional bodies. On their suggestions, an artificial mouth was opened to let in the sea water which reduced the length of the inlet channel by 18 kilometres. The resultant increase in salinity drastically brought down the spread of weed thus increasing the weed-free area. This helped the brackish water species like fish, prawn, and crab to grow, and the endangered species to receive a fresh lease of life. The average fish yield improved from a bare 1600 metric tonnes ten years ago to 11, 877 tonnnes in 2000-2001, or a sevenfold increase in comparison to the average yield prior to opening of the mouth. This gave rise to an effective collaboration between the Chilika Development Authority and the community. Indeed, awareness campaigns, environmental education, capacity building programmes, networking with the local non-Government Organisations, a newsletter in Oriya with community members contributing most of the articles have been instrumental in the restoration of the Chilika lagoon. It also involved intensive monitoring and assessment systems.

These stories emphasize the fact that a change is possible. It could be through an initiative of a group of people interested in improving their immediate neighborhood as in the case of the jheel in Kolkata or the Government as in the case of the Chilika lagoon. Often a change is possible through the initiatives and efforts of an individual, the examples being that of Anna Hazare at Ralegaon Siddhi in Maharashtra and Rajendra Singh in Rajasthan – both pioneers of watershed management (editorial, Dream 2047, August 2002). Be it an initiative from an individual, a group of people, or a Government Department, but for it to grow into a success story, it is imperative to ensure stakeholders' participation. This is how the Thames was cleaned and this is how Dhaka became free of polythene bags, and this is how we shall be able to clean up the Ganga and the Yamuna. Those who are affected and those who are concerned must decide and act together and in harmony.

(July 2003)

The Fizz and the Pesticides*

Pollution Monitoring Laboratory (PML) of the Centre for Science and Environment recently announced the results of the analysis of the contents of 12 soft drink brands sold in Delhi, and marketed in the country by the two multinational giants – Coca Cola and PepsiCo. The laboratory tests revealed that the soft drinks marketed by these companies contain pesticide residues well in excess of European Economic Commission (EEC) norms. Total pesticides in all PepsiCo brands on an average were 0.0180 milligrams per litre (mg/l) or 36 times higher than the EEC limit for total pesticides (0.0005 mg/l). Total pesticides in all Coca-Cola brands were 0.0150 mg/l or 30 times more than the same EEC limit. Mirinda Lemon is supposedly the most contaminated with 70 times the prescribed and allowed level of pesticides. PML tested the soft drink samples for 16 organ chlorine pesticides, 12 organ phosphorus pesticides, and 4 synthetic pyrethroids. All of these are commonly used as insecticides in agricultural fields as well as at home.

The four main pesticides found in the soft drinks were DDT, Lindane, Chloropyrifos and malathion (interestingly, the Cola samples from USA did not show presence of any of these contaminants!). DDT and its metabolites were detected in 81% of the soft drink samples. They have been

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* In July 2003 Centre for Science and Environment (CSE) announced that most of the soft drinks available in Indian market contain pesticide residues well in excess of European Economic Commission (EEC) norms. The editorial takes stock of the prevalent situation.

linked to altered sexual development in various species, to a decrease semen quality and to increased risk of breast cancer in women. Lindane is a deadly insecticide that damages the body's central nervous system as well as immune system and is a confirmed carcinogen. It was found in 100 per cent of cold drink samples. Chloropyrifos can cause pneumonia, muscle paralysis, even death due to respiratory failure, and is especially dangerous for mothers-to-be and babies as it is a suspected neuroteratogen (it causes malformations in foetuses). This pesticide was found in 100 per cent of the samples. The average amount of chlorpyrifos found in all samples was 42 times higher than the EEC norm. Malathion was Detected in 97 per cent of the samples. Its concentration was highest in a Mirinda lemon sample, 196 times the EEC limit for a Mirinda lemon sample, 196 times the EEC limit for a single pesticide. Coca-Cola had malathion 137 times higher than EEC norms. Malathion gets activated in the human liver to produce malaoxon, deadly for the nervous system. It is also a confirmed mutagen — it can tinker with the body's chromosomal set-up. Worst is the impact of a cocktail of pesticides. There can be a variety of effects even when each mixture component is present at concentration that individually produces insignificant effects. Even the waste product of these soft drinks is no safe – waste product from the Coke plant at Plachimada, Kerala, sold at throw away price as fertilizer to local farmers was found to contain heavy metal contaminants like lead and cadmium. Both Pepsi and Code have denied the report of pesticide presence in their products, and claim that their products are absolutely safe. Sure enough, the CSE report has snowballed into a raging controversy! The immediate fallout has been that the Colas have been banned in the Parliament independent tests for pesticides ordered by the Government in two different laboratories.

Six months ago, a study conducted by CSE for pesticide residues in bottled water had shown that most brands being sold under the ISI quality certification mark then. The Indian government has since notified new standards for pesticide residues in bottled water. The on 01 January, 2004. Incidentally, the pesticides found in soft drinks were similar to those found in bottled water.

Surely, coke and PepsiCo could not have got away in the USA or in Europe. Why does it then happen in our country? Partly, the problem is with the existing national regulations that allow the firms to be lax about standards. The detailed norms for pesticide residue limits for soft drinks constitutes “potable” water! All that exists in regulations is followed – to manufacturers! Most Cola firms use groundwater for their plants which could be contaminated. But, this following the strictest of standards as they do in USA and Europe.

How do the deadly pesticides get into the drinking water? Though the use of DDT is banned in agriculture, it continues to be widely used. Aggressive marketing by manufacturers and inadequate agricultural services have resulted in farmers spraying excessive amounts of pesticides on crops. These toxic products either remain the soil and then mix with the ground water. Agricultural and drinking water needs are increasingly met through ground water especially when the rainfall is scanty. Then the inevitable happens. Chemical residues in these resources enter the food chain or in drinking water. Let alone Colas, this is how everything we eat or drink gets pesticide residues in it. This does not include the huge quantities of industrial wastes – both, chemical and metallic – drained into our precious rivers and water bodies. We are also familiar with the sewage water mixing with ground water and giving rise to a plethora of diseases like typhoid, jaundice, gastro-enteritis and so on.

What is amazing, however, is the apathetic attitude of the people at large towards the grave concerns that directly affect their well-being and health, nay, survival. The argument I often hear is – what is this great fuss all about? What is not contaminated?! Milk is contaminated with urea and detergents, pulses and vegetables are artificially coloured, injectible dyes are present in water melon and capsicum or brinjer, papaya seeds in black pepper – and still I continue to survive! If the pesticide residues are present in the water I drink at home or outside, then how does it matter if I quench my thirst with soft drinks? Incidentally, Colas do not quench the thirst! Enquiries as a few hotels and restaurants have shown that their sales have dropped only marginally! The restaurateurs and hoteliers are confident that there will be fizz – even with pesticides – once again soon after the dust settles down.

Indeed, the real issue this controversy has thrown up is the poor quality of drinking water and food products available in the country, and with it the need to specify the norms to regulate their quality. Fallout of the CSE study has been that it has forced the Government and the people – even if only a small proportion – to think in this direction and look for a solution for a better quality of life. It is imperative that a chain reaction in initiated to sensitize and educate those with a casual attitude towards the risks they have been exposed to by the contamination of water and food products. Change is difficult, but not impossible. We can then hope for fizz without pesticides.

(August 2003)

The Challenge of AIDS

The dreaded Human Immunodeficiency Virus (HIV) was spotted by Luc Montaigner and Robert Gallo in Pasteur Institute of Paris in 1983. Ever since, scientists across the globe have been putting in intense efforts to find a cure for this scourge. Till date no drug is available that is fully effective. Apparently, HIV infections were imported into India in the early to mid -1980s. It is the HIV that eventually causes Acquired Immune Deficiency Syndrome (AIDS).The first case of AIDS in India was detected in 1986. Since then, HIV infections have been reported in all States and Union Territories. While a vaccine for AIDS still remains elusive, the number of AIDS victims battling for life is growing at an alarming rate. According to the latest statistics of the National AIDS Control Organisation (NACO), the nodal agency that coordinates all AIDS control and prevention activity in India, currently over 39.7 lakh people in India have AIDS.

Why is it so difficult to develop a vaccine that can effectively prevent AIDS? HIV is an RNA (ribonucleic acid) virus, that is, its basic genetic material is RNA. DNA (deoxyribonucleic acid) and RNA are proteins that carry genetic information. A body cell proceeds from DNA through RNA to duplication of itself. Because it has no native DNA, the virus smartly reverses the normal sequence of duplication. RNA from the virus uses the host cell's DNA to produce its own viral DNA. It is then that the normal duplication process begins. Once inside a host body, HIV primarily infects 'T' lymphocytes and monocytes which are major components of the immune system. The virus takes over the reproductive machinery and starts reproducing itself. The cell weakens and eventually dies, releasing the newly made viruses into the blood stream. Other white blood cells are invaded and they too die. This is how the body is left vulnerable to ‘opportunistic’ diseases – tuberculosis, pneumonia, meningitis and encephalitis being only a few. Despite the long incubation period of a few years to turn into full blown AIDS, the body does not have enough time to produce antibodies to ward off disease. How is that? This is due to the fact that HIV mutates at such a fast rate that by the time an antibody is produced, the virus has changed its appearance and the antibody is unable to recognize its target! The virus also escapes detection by hiding inside a host cell’s DNA or by directly moving from one cell to another cell, bypassing the blood stream. In the latter case, even if there is a specific antibody against the virus, the two will never come into contact, since the antibodies circulate in the blood.

How does HIV spread? With the exception of HIV transmission from mother to child and via infected blood / blood products, tissues or organs, all other HIV transmission occurs only as a result of those human behaviours that place an individual at risk of acquiring an HIV infection. The primary risk behaviours that place a person at significant risk of acquiring or transmitting an HIV infection include the sharing of drug injecting equipment and / or having unprotected sexual intercourse with multiple sex partners. Only those persons who are involved in some HIV-risk behaviours or whose sex partner is involved in some HIV-risk behaviours are at any risk of acquiring an HIV infection via sexual intercourse. In addition, the threat of tuberculosis related to HIV infection poses a major public health challenge due to the high prevalence of tuberculosis infection in India.

The distribution of HIV / AIDS in India is very heterogeneous. HIV epidemics are focused very sharply in a few southern States, with most of India having extremely low rates of infection. The major impact of HIV/AIDS is being felt in Maharashtra, Tamil Nadu, Pondichery, and Manipur. Since the first HIV-positive case was detected in India in 1986, the virus has moved beyond the confines of high-risk groups, such as sex workers, and entered the general population. The stigma associated with HIV/AIDS is only one of the problems faced by those unfortunate enough to get infected. The most worrying sign of this is the growing numbers of pregnant women who turn out to be HIV-positive. Active Retroviral Therapy (ART) - a combination of drugs - can prevent some of the infections associated with AIDS. However, this treatment being expensive has eluded the common man. ART provides the infected an opportunity to lead a normal life, delays onset of full blown AIDS, and reduces the transmission of HIV by infected mothers. In particular, in 1996, Brazil gave its citizens the right to free medication for HIV / AIDS, and backed by community programmes to monitor the drug consumption, was successful in stabilizing its HIV / AIDS population to half a million.

NACO estimates that there has been a 15 per cent increase in just one year in the number of new infections! Surely, prevention – through public awareness programmes and making the treatment available in public hospitals - is the only way to contain the spread of the virus that causes AIDS. However, we also have a responsibility to care for those already infected with HIV. Recently, South Africa, the country with world's largest HIV population, has taken an historic decision to begin treatment in public hospitals of its five million citizens infected with HIV. Incidentally, we are the world's second largest population affected with HIV. What hope do we have? Since at any point of time, only about 20 to 30 per cent of the infected need treatment, their treatment may only cost about Rs. 4,000 crore, equivalent to about 0.5 per cent of the GDP. This should certainly be affordable.

True, the number of people suffering from tuberculosis, malaria and diabetes is many times larger than HIV / AIDS and that these populations cannot be ignored. But in the absence of any cure, HIV / AIDS poses a unique challenge. Let us accept that we are confronted with a major health crisis. This why we need to follow the examples of Brazil and South Africa without any delay. Spreading awareness about HIV / AIDS is everybody's responsibility – mine and yours. Let us contain the virus before it gets fully blown up.

(September 2003)

Venus Transit – A Rare Celestial Spectacle

On 24 October 1995 and 11 June 1999, we had a rare opportunity of witnessing a Total Solar Eclipse from India, when millions observed and enjoyed one of the most spectacular phenomena of nature. When Moon comes in between the Earth and the Sun, it is the solar eclipse. However, when either Mercury or Venus – either of the interior planets - comes in between the Sun and the Earth, it is called a transit. In a few months from now, we shall have the good fortune of watching Venus move across the disc of the Sun.

The discs of the planets Mercury or Venus, as seen from Earth, are much smaller than that of the Moon. Therefore they make no more than a small black dot when they move in front of the face of the Sun. With every transit, depending on the geometry involved, this dot may traverse a different path across the face of the Sun. The transits do not take place frequently because the orbits of both Mercury and Venus are tilted at small angles to the ecliptic (the average plane of Earth's orbit around the Sun – the planets are always seen close to it), and hence they will usually be either above (north) or below (south) the ecliptic. This also the reason why we do not have solar eclipse on every new Moon day, or lunar eclipse on every full Moon day – the Moon ay be somewhat above or below the ecliptic. A transit will occur if the inferior conjunction occurs within a day or two (that is, the Sun, planet and the Earth coming on the same line with the planet in between) of the date at which the planet crosses the ecliptic.

The transits of Mercury can be seen 13 to 14 times in a century (incidentally, the first transit of Mercury in the twenty first century took place on 07 May 2003 which was visible in the entire country). However, transits of Venus across the disk of the Sun are among the rarest of planetary alignments. Indeed, only six such events have occurred since the invention of the telescope (1631, 1639, 1761, 1769, 1874 and 1882). It is interesting to note that there is no person living today who has witnessed a Venus transit before, the last transit having taken place 121 years ago, 06 December, 1882 to be precise. Venus transits show clear pattern of recurrence at intervals of 8, 121.5, 8 and 105.5 years. The next two transits of Venus will occur on 08 June 2004 and 06 June 2012. The entire transit of 08 June 2004 will be visible from Europe, Africa (except western parts), Middle East, and most of Asia (except eastern parts). India is ideally suited to observe the entire sequence of transit. We are very fortunate indeed.

What is the significance of transits? Edmund Halley realized that transits could be used to measure distance of the Sun from the Earth, also called Astronomical Unit. Kepler's laws gave relative distances between all the planets and the Sun, but, the absolute distances were not known. Halley did not live to see Venus transits in his lifetime, but, his efforts gave rise to many expeditions in 1761 and 1769 to observe the transits of Venus which gave astronomers their first good value for the Sun's distance from Earth. By timing the events from various places on the Earth and using elementary geometry, the distance to the Sun can be determined. More accurate methods are available now, but careful measurements in the 18th and 19th centuries gave distances to within 1% of that currently accepted.

The stories of expeditions all over the globe to observe the transits of Venus in the 17th and 18th centuries are as thrilling as they are inspiring. Captain Cook had observed a transit of Venus from Tahiti in June of 1769 and one of

Mercury from Mercury Bay in New Zealand in November of the same year. In India too, there had been some observations of transits but no rigorous measurements could be taken to have been of much scientific value. Observations were planned from Pondicherry, for the Venus transit of 1761 by Le Gentil of France. He set out on a long sea voyage to India, in order to be in time for this transit. Unfortunately, Britain and France were at war during this period and when he was about to land in Pondicherry it had been taken over by British forces! He stayed on for observing the next transit in 1769, but the weather did not permit him! William Crawford observed the 1874 transit from Mauritius. Ernst Emil Becker of the Berlin Observatory made observations of the 1874 transit from an expedition to Isaphan. The first scientific observations made in 1882 by the Yale Heliometer, then largest in the world, were of the 1882 Venus transit.

While a transit of Mercury or Venus offers a great opportunity to the scientists to measure the planetary distances from the Sun, it provides a great occasion to science communicators to utilise the spectacular event to communicate the basic scientific aspects related to several astronomical phenomena in particular, and Science & Technology (S&T) in general to the members of the community. To capitalise on the tremendous possibilities offered for Science and Technology popularisation, Vigyan Prasar and National Council for Science and technology Communication have drawn up plans that include a variety of programmes for students, teachers and the general public. The main objective of the proposed programme is to utilise the event of Venus Transit for triggering an interest in Science and technology. A spate of activities would involve students, teachers and the general public. But remember! Do not try to observe the transit without taking proper precautions, or else your eyes could be permanently damaged.

08 June 2004 is our date for rendezvous with Venus, a rare phenomenon which would take place after a gap of 121 years. As during the Total Solar Eclipses of 1995 and 1999, this would be an event in which students, teachers, general public, and Government / non-Government organisations, would be involved. We do hope you would be a part of this nation-wide S&T popularisation programme. Please do write to us about your ideas and suggestions.

(November 2003)

Quest for Excellence

The year 2003 was remarkable for several landmark discoveries and achievements in Science and Technology. Scientists unearthed in Ethiopia three 1,60, 000 year old skulls that they say are the oldest near-modern humans on record. The new find lends support to the so called Out of Africa hypothesis, which states that Homo Sapiens arose as a new species between 150,000 and 200,000 years ago in Africa and subsequently replaced archaic humans such as the Neanderthals. Researchers developed a super-sticky adhesive modelled on the foot of gecko lizard that grips even the slipperiest of surfaces. As it turns out, the sole of the gecko foot is covered with millions of submicron hairs that apparently stick the animal to the substrate by way of intermolecular van der Vaals forces. NASA's Wilkinson Microwave Anisotropy Probe helped compile a full sky map that reveals our universe in its earliest stages pinpointing the age of the universe at 13.7 billion years. Astronomers detected thousands of light years away in the globular cluster known as M4 the most ancient planet yet known orbiting a binary system with a mass 2.5 times that of Jupiter. A foal born in Italy earlier in the year and named Prometea was the first successfully cloned horse. Another exciting story reported related to the landmark experiment through which the speed of gravity was measured for the first time confirming Einstein's predictions that gravity travels at the speed of light. We celebrated the 50th anniversary of the discovery of the double helix structure of DNA by James D. Watson and H. C. Crick, and a hundred years of powered flight by Orville and Wilbur Wright. China's great leap into space towards the end of the year was yet another landmark. The year 2003 also marked 75 years of the discovery of Raman Effect.

If there were triumphs in the year gone by, there were tragedies too. On 01 February, 2003, the crew of seven astronauts of the Space Shuttle Columbia was lost when it exploded on re-entry when they were only sixteen minutes from home. One of them was Kalpana Chawla, who dreamed stars, but did not return home. The outbreak of SARS (Severe Acute Respiratory Syndrome) in several countries that migrated from the Guangdong province of China caught the entire world off the guard. However, it taught us a lesson. Information sharing is crucial to ward off the coming danger. It was because of ignorance, fear and lack of sharing of information that SARS migrated from China to several countries across the globe. The war in Iraq brought about great upheavals in the world order, and a devastating earthquake in Iran claimed over 30,000 people razing to the ground the historic city of Bam.

It is important to realize that many tragedies can be avoided or their effect mitigated by sharing information and spreading awareness among the people about the environment - both physical and social – and development of a scientific outlook. Incidentally, scientific awareness and scientific outlook have been emphasized in the Science and Technology Policy released in 2003. Further, in view of the changing economic and social scenario, we need to deliberate on the complex issue of scientific awareness and scientific outlook all afresh and evolve a suitable strategy and ways and means for its implementation. This demands excellence at every stage – say, conceptualization, planning, coordination and implementation. May be this is why the focal theme of the 91st session of the Indian Science Congress held in Chandigarh during 3-7 January 2004 was “Science and Society in the 21st Century: Quest for Excellence”, and the year 2004 declared as the Year of Scientific Awareness.

Quest for excellence does not necessarily imply huge investments in terms of money. Indeed, excellence can be achieved even with very limited resources. Excellence implies encouragement to experiment, freedom to tinker around, think freely and express oneself without fear. We need a conscious, systematic and a sincere effort to achieve "excellence" in our schools and universities. Let us make this "heaven of freedom" available to our children in our homes, schools and universities. Coming years then would bring more triumphs than tragedies.

(January 2004)

Roving on Mars*

In 1877, Giovanni Virginio Schiaparelli (1835-1910), an Italian astronomer, produced the first "modern" map of Mars, on which he showed a system he termed *canali*. *Canali* in Italian means "channel" and the word was translated into English as "canal" implying intelligent design! In 1910, Percival Lowell (1855-1916), an American astronomer and discoverer of the planet Pluto, painted a compelling portrait of a dying planet, whose inhabitants had constructed a vast irrigation system to distribute water from the polar regions of Mars.

Further, his idea of an "Earthlike" Mars proved more exciting. At the dawn of the space age, Mars was considered to have an atmosphere about a tenth the density of Earth's, water ice polar caps that waxed and waned with the seasons, and an annual "wave of darkening" that was often interpreted as growing plant life. However, in the 1960s, observations from Earth and flyby spacecraft signalled the beginning of the end for Lowell's Mars. The *Mariner 4, 6*, and *7* missions of USA returned images of a moonlike, heavily-cratered surface. The atmosphere was found to be almost pure carbon dioxide and only a hundredth the density of Earth's, and the polar caps proved to be almost entirely frozen carbon dioxide. The first global views of Mars, returned by the *Mariner 9* orbiter in 1972, revealed that the planet was far more complex than the earlier flyby missions had shown, with huge volcanoes, an enormous

* NASA's exploration rovers *Spirit* and *Opportunity* landed on Mars surface in January 2004. The editorial provides an historical account on different Mars missions, their findings and future prospects.

canyon system, and evidence of running water *at some point in the past*. But the wave of darkening was shown to be the result of seasonal redistribution of wind-blown dust on the surface. The atmosphere's composition and density were confirmed, and most of the evidence for an Earthlike Mars was swept away.

But despite all these blows, the possibility of organisms on the surface could not yet be ruled out. For this reason, in 1976 the USA *Viking* landers – *Viking 1* and *Viking 2* - carried a sophisticated instrument to look for possible life forms on the Martian surface. Both the landers had experiments to search for Martian micro-organisms. The landers provided detailed colour panoramic views of the Martian terrain. They also monitored the Martian weather. They, however, could not detect any traces of life on the two landing sites which were widely separated and different in character. As of today, the chances that life exists on Mars do not seem very good. However, there are reasons to believe that Mars may have been significantly wetter, perhaps with a denser atmosphere, earlier in its history. If so, there is the possibility that life arose on Mars, only to die out as conditions on the planet worsened. This is why some scientists have suggested that future searches for life on Mars be shifted to focus on *extinct* life rather than *extant* life.

Nearly two decades after the *Viking* missions, there has been a spurt of activity on the Martian surface once again. *Mars Pathfinder - USA Lander* and *Surface Rover* arrived at Mars on July 4, 1997, and two days later a six-wheel rover, named *Sojourner*, rolled onto the Martian surface. *Mars Pathfinder* returned thousands of images from the lander as well as more than 15 chemical analyses of rocks and extensive data on winds and other weather factors. NASA's twin robot geologists - *the Mars Exploration Rovers* - were launched toward Mars on 10 June, 2003 and 7 July, 2003 respectively, in search of answers about the history of water on Mars. "*Spirit*" landed on its surface on 03 January, 2004, while "*Opportunity*" landed on 24 January, 2004. Spirit fell sick for a few days, but was healthy once again! *Spirit* and *Opportunity* would roll out, collect rock and soil samples and analyse them for clues to past water activity and determine whether life ever arose on Mars. They would also characterize the climate and geology of Mars, and prepare for human exploration in the years to come.

The big science question for the *Mars Exploration Rovers* is how past water activity on Mars has influenced the red planet's environment over time. While there is no liquid water on the surface of Mars today, the record of past water activity on Mars can be found in the rocks, minerals, and geologic landforms, particularly in those that can only form in the presence of water. That's why the rovers are specially equipped with tools to study a diverse collection of rocks and soils that may hold clues to past water activity on Mars. The spacecraft are targetted to sites on opposite sides of Mars that appear to have been affected by liquid water in the past. The landing sites are at Gusev Crater, a possible former lake in a giant impact crater, and Meridiani Planum, where mineral deposits (hematite) suggest Mars had a wet past.

Meanwhile, NASA Mars orbiters - *Mars Global Surveyor* launched on 07 November, 1996 and the *2001 Mars Odyssey* launched on 07 April, 2001 – continue to orbit Mars carrying out important observations and providing support to the rovers. *The Mars Express* – Mars orbiter and lander - launched by European Space Agency on 01 June, 2003 met only with partial success. Its lander *Beagle 2* did not return any signals after it separated from the spacecraft. *Mars Express*, however, continues to orbit Mars and transmit valuable data to the Earth. Indeed, Mars never saw such a feverish activity when five spacecraft simultaneously had a brush with it!

What is important to note is that it took nearly 37 missions spread over 5 decades of concerted efforts to land the rovers on Mars. It may be a few more decades before humans set their foot on the Red Planet and take a "small step" on its surface. Mars is a spectacular place, and will remain so even if it is finally proved to be lifeless. Nearly a year ago, 01 February, 2003 to be precise, the Space Shuttle *Columbia* disintegrated on its return journey when it was just 16 minutes away from the Earth. The entire crew of seven astronauts perished. Kalpana Chawla - the citizen of the Universe - was one of them. Spirit and Opportunity roving on the surface of Mars are a fitting tribute to these martyrs who helped push the frontiers of our knowledge. Today, we may not be sure if there is or ever was life on Mars. But one thing is certain - one day, there will be!

(February 2004)

Internet — How it all began

Personal computers came to India only about twenty years ago, and Internet in India as we know today is only about ten years old. Yet it is difficult to think of life without access to Internet! Be it e-mail, chat, news, job hunting, product info, shopping on the net, entertainment, contests, rail or air tickets, downloading software or games, matrimonial alliance and so on - the list is growing!

How did it all begin? Some 40 years ago, the RAND Corporation, America's foremost Cold War think tank came up with a proposal for a communication network that would have "no central authority" and which would be "designed from the beginning to operate while in tatters." The principles were simple. The network itself would be assumed to be "unreliable" at all times, and would be designed from get-go to transcend its own unreliability. All the nodes in the network would be equal in status to all other nodes - each node with its own authority to originate, pass and receive messages. The messages themselves would be divided into packets with each packet separately addressed. Each packet would begin at some specified source node, and end at some other specified destination node. Further, each packet would wind its way through the network on an individual basis. The particular route that the packet took was unimportant. Only final results would count. The packet would be tossed from node to node, more or less in the direction of the destination, until it ended up in the proper place. This rather haphazard delivery system might be "inefficient" in the usual sense, but it is extremely rugged.

During the 60s this intriguing concept of a decentralized, blastproof, packet-switching network was kicked around by

RAND, Massachusetts Institute of Technology and University of California, Los Angeles. Pentagon's Advanced Research Project Agency (ARPA) embarked upon a more ambitious project in the USA. The nodes of the network were to be high speed computers. At that time, these were rare and valuable machines which were in real need of good solid networking, for the sake of national research and development projects. In 1969 the first such node was installed in UCLA. By December 1969, an infant network came into being with four nodes, called ARPANET, after its Pentagon sponsor. The four computers could transfer data on dedicated high speed transmission lines. They could even be programmed remotely from other nodes. Scientists and Researchers could share one another's computer facilities by long distance. In 1971, there were 15 nodes in ARPANET and in 1972 there were 37. Throughout the 70s ARPA's Network grew. Its decentralized structure made expansion easy. ARPA's original standard for communication was known as Network Control Protocol or NCP. As time passed and the technique advanced NCP was superseded by a higher level more sophisticated standard known as TCP/IP. TCP or Transmission Control Protocol converts messages into streams of packets at the source, then reassembles them back into messages at the destination. IP or Internet Protocol handles the addressing, seeing to it that packets are routed across multiple nodes and even across multiple networks with multiple standards. In 1983 the military segment of ARPANET broke off and became MILNET. ARPANET itself expired in 1989.

As the 70s and 80s advanced, different social groups found themselves in possession of powerful computers. It was fairly easy to link these computers to the growing network of networks. Since the software called TCP/IP was public domain, and the basic technology was decentralized, it was difficult to stop people from barging in linking up somewhere or the other. This is what came to be known as the "Internet". The nodes in the growing network of networks were divided up into basic varieties, say, gov, mil, edu, com, org and net. Such abbreviations are a standard feature of the TCP/IP protocols. The use of TCP/IP standards is now global. Today there are thousands of nodes in the Internet scattered over the hundreds of countries with more coming online everyday.

The Internet has grown into a network of networks, linking computers to computers sharing protocols called TCP/IP. Each runs software to provide or "serve" information and / or to access and view information. Surely, the Internet is the transport vehicle for the information stored in files or documents or another computer. It is an international communications utility servicing computers. It is a misstatement when one says that "I found the information on the Internet!" In fact, what one means is that the document was found through or using the Internet – on one of the computers linked to the Internet - the Internet itself does not contain information. The World Wide Web (WWW or the Web) incorporates all of the Internet services mentioned above and much more. We can retrieve documents, view images, animation and video, listen to sound files, speak and hear voice, and view programmes that run on practically any software in the world provided our computer has the hardware and software to do these things.

Internet made its entry in India in 1988 when several Indian Universities joined the net. Internet was very different then than what it is today. Few outside a small group of researchers and technicians knew of the internet, and they used it primarily for sharing technical information and facilitating the development of standards and networking technology. It was only in early 90s that Internet became a familiar term in our country. Internet has continued to expand ever since in a steep manner. India's active Internet subscribers were estimated at 1.5 million by March 2002. NASSCOM (National Association for Software and Services Companies) forecasts that the number of Internet subscribers will rise to 7.7 million by the year 2004/05 with the user base rising to 50 million. However, it is interesting to note that nearly 70 per cent of users are between the age group 15-30. Nearly 75 per cent of users are male and 25 per cent female, but the scenario is fast changing. Internet users still belong to the higher income group, but with the costs of hardware and software coming down, more and more people shall have access to Internet. Creation of a separate Ministry of Information Technology and a sound proactive policy have helped the growth of IT sector and hence Internet in our country. The impact of Internet is already visible in our country. It has opened up a huge reservoir of information and knowledge alongwith immense possibilities in the fields of education, development and efficient governance. What started as a network of four nodes in 1969 has grown into a gigantic network of networks, and continues to grow.

(March 2004)

The Sixth Wave

Over the last 600 million years of the geological history, the mass extinction has been witnessed five times though separated by millions of years. The Palaeozoic era (590 to 248 million years ago) witnessed the mass extinction thrice - during the period 505 to 438 million years ago (Ordovician period), during the period 408 to 360 million years ago (Devonian period), and during the period 286 to 248 million years ago (the Permian period). It was during these periods that several invertebrate and vertebrate groups of animals, fish and amphibians evolved and died. The first forests also appeared in this period. In particular, during the Permian period, the climate was dry and hot causing extinction of many marine animals and proliferation of reptiles. The next two waves of extinction were in the Mesozoic era (248-65 million years ago) – during the period 248 to 213 million years ago (Triassic period) and during the period 144 to 65 million years ago (Cretaceous period – between Jurassic and Tertiary periods). It was during this era that dinosaurs became numerous. The climate was warm and sea level rose. First flowering plants emerged. Domination of dinosaurs continued, but they died out towards the end of the Cretaceous period. This is said to be due to the catastrophic impact of one or more meteorites. A drastic climate change is also attributed to the extinction of dinosaurs and many other organisms at this time. Indeed, the possible causes of the five waves of mass extinction were natural - global warmings and coolings, devastating meteorite showers, volcanic activities and so on.

However, disappearance of some species or what is also called extinction, and appearance of others is a natural process that forms the basis of organic evolution. According to the fossil records, no species has yet proved immortal. What is interesting is the fact that as few as only 2 to 4 per cent of the species that have ever lived are believed to have survived till date. The remainder are extinct - the vast majority having disappeared long before the arrival of human beings!

In a recent issue of the journal Science, an extensive study on the extinction of birds, butterflies and vascular plants in Britain has been presented. The study is based on large sets of data collected over the past 20 to 40 years in England, Wales and Scotland and analysed at the Natural Environment Research Council Centre for Ecology and Hydrology in Dorchester, UK. If the results are to be believed, then, a sixth massive extinction event in the history of life is upon us yet again. The study shows a 28 per cent decline of native plants, a 54 per cent decrease in abundance of native birds and a 71 per cent decline of butterflies! There appears to be a concrete evidence that insects which account for more than half the described species on Earth are disappearing faster than the birds! This supports the view that the world is indeed on the verge of another great species wipeout.

The rapid loss of species of flora and fauna on the Earth that we are witnessing today is estimated to be between 1,000 and 10,000 times higher than the background or expected natural extinction rate - estimated at one species every four years. Why is it so? What could be the reason for the unusual rate of extinction of birds, butterflies and plants? Something as subtle but widespread as habitat loss and degradation because of the human activity could be the plausible reason, compounded by depletion of the ozone layer and greenhouse effect, deforestation and toxic pollution of the soil and water. Overexploitation of resources like water and forests, agricultural activities, extraction (mining, fishing, logging, harvesting etc) and development (human settlements, industry and associated infrastructure) – all have an adverse impact. Habitat loss and fragmentation leads to the formation of isolated, small, scattered populations. These small populations are increasingly vulnerable to inbreeding depression, high infant mortality and consequently, in the end, possible extinction. Unlike the mass-extinction events of geological history that snuffed out innumerable species from the Earth five times earlier, the current extinction phenomenon is one for which a single species – human beings - appears to be almost wholly responsible for the sixth extinction crisis.

India's animal species account for 7.31 per cent of the faunal species in the world and the flora account for 10.78 per cent of the global total. About 33 per cent of the country's recorded flora are concentrated mainly in the North-East, Western Ghats, North-West Himalayas and the Andaman and Nicobar islands. However, this rich biodiversity of India is under severe threat owing to habitat destruction, degradation, fragmentation and overexploitation of resources. According to the Red List of Threatened Animals published in 2000 by International Union for Conservation of Nature, India's 44 plant species are critically endangered, 113 endangered and 87 vulnerable. Amongst animals, 18 are critically endangered, 54 endangered and 143 are vulnerable. India ranks second in terms of the number of threatened mammals and sixth in terms of countries with the most threatened birds. In India, poaching is another insidious threat as one of the primary reasons for the decline in numbers of species, such as the tiger.

True, the underlying causes of biodiversity loss are poverty, economic policies, international trade factors, policy failures, poor environmental laws and / or their weak enforcement, unsustainable development projects and lack of local control over resources. Needless to say that it takes enormous efforts at all levels, from individual to global, to halt species extinction. Data on species, their habitat and threats would need to be periodically collected and analysed to evolve appropriate strategies to prevent their loss. We must act in right earnest now. The time is running out. No doubt, in earlier extinctions life had always bounced back firmly in all its multiplicity. But, it required millions of years to do so. That may be a blink in geological terms but is considerably longer when viewed against human life span or even human civilization. Most ecologists accept that we are approaching the rates of extinction seen in the past five mass extinctions. The culprit for the current wipe-out is us. We need to quickly develop the capacity to foresee and forestall the sixth extinction wave, or else we shall end by destroying the Earth.

(April 2004)

Two Centenaries and a Golden Jubilee

The year 2004 marks the death centennial of Jamsetji Nusserwanji Tata, the founder of the Tata Group and the birth centennial of Jehangir Ratanji Dadabhoy Tata. Both were great nation builders whose contribution in industrializing India and making her self-sufficient in basic areas in the twentieth century has been unparalleled. Both were visionaries with a firm belief that the social and economic development of a country is closely linked with self-sufficiency and the self-reliance arising out of the scientific and technological advances made by the country. Jamsetji Nusserwanji Tata was born on 13 March, 1839 into a clerical Parsi family in Navsari, Gujarat. Jamsetji Tata created the foundations of Indian enterprise. Indeed, this was an expression of pride that the country could do something, that it could make textiles, manufacture steel, and generate power.

He adopted international standards. He was a true internationalist in that sense and, yet, a committed nationalist. His goal of political and economic self-sufficiency had the effect that the British did not raise him to the rank of nobility as they did with other Parsi entrepreneurs. He faced opposition from the government for many of his projects, including the founding of the steel industry. However, his vision of the Institute of Science in Bangalore, a steel plant in Jamshedpur, and a hydroelectric company were brought to fruition by his successors. He once said, " Freedom without the strength to support it and, if need be, defend it, would be a cruel delusion. The strength to defend freedom can itself only come from widespread industrialisation and the infusion of modern science and technology into the country's economic life". He died on May 19, 1904 in Bad Nauheim, Austria.

Jehangir Ratanji Dadabhoy Tata, or JRD as he was popularly called, was born on 29 July, 1904 in Paris and spent much of his childhood in France. His father was Ratanji Dadabhoy Tata, a cousin of Jamsetji Nusserwanji Tata. JRD was a committed nationalist. He was proud of India and tremendously passionate about building a vibrant nation with an open economy and a free-enterprise structure. He shaped the Tata Group. He was at the helm of affairs of Tata & Sons for over fifty years. Under his stewardship, it became India's largest industrial empire with number of ventures growing from 13 to about 80. Tata Chemicals, Tata Engineering and Locomotive Company (TELCO), and Tata Consultancy Services were only a few of his creations.

Flying was true love of JRD. His passion for flying was fulfilled with the formation of the Tata Aviation Service in 1932. The first flight of Indian Civil aviation took off at Drigh Road airfield in Karachi on October 15, 1932, with JRD himself at the controls of the Puss Moth that he flew solo to Ahmedabad and onwards to Mumbai (then Bombay). After India gained independence, Air India International was formed as a joint sector company. Equally historic was his role in launching India into the age of nuclear science by lending support to Homi Bhabha in the establishment of Tata Institute of Fundamental Research. He was also on the Board of the Atomic Energy Commission since its inception in 1977. Tata Memorial Hospital in Mumbai established by him carries out triple objects of treatment, research and education. He played the part of statesman in India and abroad and even espoused causes like family planning and the plight of the girl child. He died on 29 November,1993 in Switzerland.

The year 2004 also marks the fifty years of the "Madras Triple Helix", the molecular model proposed for the fibrous protein collagen by Professor Gopalasamudram Narayana Ramachandran (08 October, 1922 - 07 April 2001), physicist turned outstanding structural biologist, and his group. About one quarter of all of the protein in our body is collagen. Collagen is a major structural protein, forming molecular cables that strengthen the tendons and vast, resilient sheets that support the skin and internal organs. Though collagen is a relatively simple protein, its structure remained a mystery till 1954.

After his Bachelor's (Honours) degree in physics, Ramachandran joined the Department of Physics, Indian Institute of Science, Bangalore, the Institute founded by Jamsetji Nusserwanji Tata. He worked with Sir C. V. Raman. Ramachandran worked on a number of problems related to light scattering, optics, crystal perfection and so on. Ramachandran spent two years at the Cavendish Laboratory before returning to India to become Professor and Head of the Department of Physics, University of Madras in 1952. It is here he completely shifted his interest to the application of X-ray diffraction to the study of biomolecules. It is part of history that the young Ramachandran along with G. Kartha within a span of two years proposed the triple helical structure for collagen. Incidentally, this was just a year after the double helical structure for DNA by Watson and Crick was propounded. Ramachandran thus joined the big league of structural biologists when he was hardly 32.

Ramachandran went on to enunciate the fundamental stereochemical principles for conformational analysis of proteins through the famous Ramachandran plot. Ramachandran received many honours from India and abroad. He was elected Fellow of the Royal Society in 1977. More recently, in 1999, he was awarded the Ewald Prize by the International Union of Crystallography. Ironically these honours came to Ramachandran late in his life, long after he had made his seminal contributions. He was a lover of classical music and the game of cricket. There is no gainsaying the fact that Ramachandran was undoubtedly one of the greatest scientists independent India has ever seen. However, it is rather sad, not many in our country are aware of this genius, nor his contributions. He died on 07 April, 2001 at Chennai.

To make people aware of Ramachandran's monumental work, and help our youth derive inspiration from his illustrious life, Institute for Genomics and Integrative Biology (IGIB) at Delhi headed by Dr. Samir Brahmachari – a student and a colleague of Ramachandran - has taken the lead to celebrate the Golden Jubilee of the discovery of the Triple Helix of collagen molecule, reported in Nature on 07 August, 1954. Vigyan Prasar also is a partner with IGIB. Indeed, it is imperative that we make our children aware of the great contributions made by Jamsetji, JRD, and G. N. Ramachandran; and the values they cherished through a variety of programmes, means and modes during this special year with two centenaries and a Golden Jubilee. This would be the best tribute to these great personalities of our country.

(July 2004)

Into ever-widening thought and action

Until three decades ago, black holes were awesome creatures that boggled the imagination. Black holes were first suggested over a hundred years ago, but their existence could be ascertained by solutions to Einstein's equations for general relativity only in the early part of 20th century. What are black holes? Black Holes represent the final stage of evolution for some very massive stars following total gravitational collapse. When a star with mass about one and a half times the mass of the Sun has burnt all its fuel, it would not be able to support itself against its own gravity. The star then explodes into a supernova. The stuff that is left collapses down to an extremely dense object known as a neutron star. If the star is too large, say about twice the mass of the Sun or more, the gravitational forces overwhelm the pressure gradients and collapse cannot be halted. The star continues to shrink until it finally becomes a black hole. A black hole is a region of space-time from which nothing, not even light, can escape, because gravity is so strong. Because of its strong gravitational field, it can gobble up matter and light from the outside. It has even been suggested the end of the universe will be its becoming a single black hole!

This was our understanding of the black holes until Stephen Hawking, the famed cosmologist, published in 1974 a landmark paper titled "Black Holes Ain't So Black." Hawking showed that due to quantum effects, black holes slowly radiate particles into the surrounding space — essentially an infinitesimal trickle of particles, that later on came to be known as the Hawking radiation. Most physicists quickly accepted Hawking's idea. As the black hole evaporates, its size decreases and it evaporates even more rapidly in a flood of Hawking radiation.

Hawking further argued that anything swallowed by a black hole remained forever hidden from the outside universe. What comes out of a black hole when it radiates will be different from what fell in! Only the energy will be the same. The black hole would gradually evaporate and then disappear in a final explosive outburst – taking with it the crucial information about how it was formed forever. Hence black holes would not preserve any record of the material they swallowed. In other words, we cannot retrace the history of the black hole from the particles and the radiation it emitted. Hawking and a few experts in general relativity argued that the extreme gravitational forces in a black hole would literally scrunch the information out of existence. Physicists, however, did not feel at ease with this conclusion, since it violated a fundamental principle of quantum mechanics – the theory that explains the behaviour of matter and energy at subatomic level. In quantum mechanics, it should always be possible to theoretically trace back the initial conditions of a physical system to its origin. Hence, most physicists thought that a black hole must somehow retain a memory of the material from which it was formed.

Recently, in the 17th International Conference on General Relativity and Gravitation in Dublin, Ireland, Hawking admitted that he was wrong. He now believes that black holes do not destroy everything that is sucked into them. Instead, information which describes the core characteristics of every type of particle, leaks from the black hole over time. In other words, if one were to jump into a black hole, one's mass energy would eventually be returned to the universe, but in a mangled form which nevertheless would contain the information about what one had been like. In 1997, John Preskill, physicist at Caltech and Hawking made a bet for a baseball encyclopaedia as to whether black holes preserve information. Preskill bet yes, Hawking bet no! Soon after conceding the defeat, Hawking bought the encyclopaedia and got it shipped across the Atlantic to Preskill.

In his presentation at Dublin, Hawking used a concept known as imaginary time, and argued that in imaginary time, black holes preserve information. But many physicists do not think the paradox can be resolved this way. "We should stick with real time, not imaginary time," says physicist Samir Mathur of Ohio State University. Earlier this year, Mathur and his colleagues used string theory to show how black holes can indeed preserve information. Though physicists agree with Hawking's conclusion, they do not buy his argument! Did he go wrong once again? But, how can we expect any progress if we do not make mistakes?

What we have described here is Stephen Hawking's constant struggle for three decades to explain an elemental paradox in scientific thinking despite a crippling disease that does not allow him to write or even to speak clearly. He is neither afraid nor shy of telling the world that he was wrong. Anyone can make mistakes or jump to wrong conclusions. But, greatness lies in admitting the mistakes and taking corrective measures, alongwith clear stream of reason and tireless striving for perfection. This is scientific spirit in the true sense.

Mistakes are the road to progress provided we learn from them. This holds true not only in pursuit of science and at individual level, but also in every field of human activity and even at national level. Let us not be afraid of making mistakes, and let us not feel shy of admitting them, but let us ensure we do not repeat them in future. We shall then be led forward into ever widening thought and action.

(August 2004)

Satellite for Education, Science and Technology*

It was in 1975-1976 that beaming educational programmes through satellites was successfully demonstrated for the first time by India. Famous in the history of Distance Learning Technology as the Satellite Instructional Television Experiment (SITE), it was conducted using the American Applications Technology Satellite (ATS-6). Indeed, this was a unique experiment which was hailed as the largest sociological experiment conducted anywhere in the world. Programmes related to health, hygiene and family planning were telecast directly to about 2400 Indian villages spread over six States and 45,000 teachers trained. To receive the programmes, television sets with direct reception facility were provided in the community centres of these villages. Ever since the advent of INSAT system in 1983, a variety of educational programmes are being regularly telecast. Yet another landmark was the Jhabua Developmental Communication Project in Madhya Pradesh and the Training and Developmental Communication Channel – both conceptualized and executed by the Development and Educational Communication Unit (DECU) of ISRO - that further demonstrated the utility and efficacy of satellite technology for education.

It was with the success and efficacy of the INSAT series of satellites for educational services that ISRO conceived the EDUSAT project – a satellite for education – in October 2002.

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* ISRO successfully launched *EDUSAT* on 20 September 2004 from Satish Dhawan Space Centre at Sriharikota. This editorial explores its potential, utilisation and possibilities in education.

EDUSAT was successfully launched on 20 September, 2004 from the Satish Dhawan Space Centre at Sriharikota using India's own Geosynchronous Satellite Launch Vehicle (GSLV) making it the first exclusive satellite for serving the educational sector. EDUSAT would provide an interactive satellite based distance education system for the country utilizing audiovisual medium, and employ Direct To Home (DTH) quality broadcast. It is important to note that EDUSAT will have multiple regional beams covering different parts of India - five Ku band transponders with spot beams covering Northern, North-Eastern, Eastern, Southern, and Western regions of the country, a Ku band transponder with its footprint covering the Indian mainland region and six C band transponders with their footprints covering the entire country. Incidentally, transponders are electronic devices that receive, amplify and re-transmit electromagnetic signals sent from ground stations. This is how a programme is beamed to and from satellites.

There is no gainsaying the fact that education is an instrument of social change. Literacy and universalisation of education remain the top priority both in India and other developing countries. In India, the problem is compounded by the fact that we have several language groups with diverse cultures separated by vast geographical distances.

As a result, imparting quality education to remote and rural areas becomes a mammoth challenge. Further, the lack of adequate rural educational infrastructure and nonavailability of good teachers in sufficient numbers further aggravates the problem. It is here that satellites can play a vital role by establishing connectivity between urban educational institutions that have adequate infrastructure to impart quality education, and the large number of rural and semi-urban educational institutions that lack the necessary infrastructure. A single teacher can simultaneously teach thousands of students in different schools/colleges across the country. From a television studio, the teacher can explain a topic, and in colleges with reception facilities, students can see and listen to him. If they have interactive facilities, the students can also put questions and get the answers. One advantage EDUSAT has is it has regional beams. Hence teachers can conduct classes in regional languages.

Surely, EDUSAT is meant for providing connectivity to school, college and higher levels of education and also to support non-formal education including developmental communication. Once commissioned, the first two years of EDUSAT will mark the semi-operational phase in which it is estimated that programmes from EDUSAT can reach 1,000 classrooms and 50,000 students. It is expected that these numbers would rise manifold as institutions gain familiarity and confidence, and the technology spreads and finds new users. Content generation, however, would be the responsibility of the user agencies. Needless to say, the quantity and quality of the content would ultimately decide the success of EDUSAT System. When EDUSAT network becomes fully operational, ISRO will provide technical and managerial support in the replication of EDUSAT ground systems to manufacturers and service providers.

One of the EDUSAT channels on the beam covering the entire country will be exclusively for Science and Technology communication, for initiating a Science Channel for India called "Jigyasa". Hence, EDUSAT would in effect stand for a satellite for Education, Science, And Technology. The credo for the channel would be - science is everywhere and for everyone. DECU and Vigyan Prasar are partners in managing the channel as well as production of software. Initially, however, it is planned to launch a pilot project on Doordarshan and then gradually shift to the EDUSAT channel.

Indian Science and Technology must make a greater difference to the lives of our people – this is what Dr. Manmohan Singh, Hon'ble Prime Minister of India, had said at the Shanti Swaroop Bhatnagar Awards ceremony recently. EDUSAT will strive to meet that objective and as predicted by Mr. G. Madhavan Nair, Chairman, ISRO, it would propel India into a leadership role in distance education. The benefits of EDUSAT could even reach beyond India's borders. As EDUSAT covers other South Asian countries partially or fully, it should be possible to extend support to those countries too, according to Mr. Nair.

(October 2004)

The Tragedy Lives On*

The Union Carbide built a pesticide factory in Bhopal in 1970s considering that India represented a huge untapped market for its pest control products. However, droughts and floods rarely left any money with the Indian farmers to buy Union Carbide's pesticides. Sales never met the company's expectations. As a result, the plant never reached its full capacity and ceased active production in the early 1980s. However, vast quantities of dangerous chemicals remained. Three tanks continued to hold over 60 tonnes of methyl isocyanate – popularly called MIC. MIC is a particularly reactive and deadly gas, but the safety system was allowed to fall into disrepair. May be, the management thought that since the plant had ceased all production, no threat remained.

On the night of 2 and 3 December 1984, when an employee was flushing a corroded pipe, multiple stopcocks failed and allowed water to flow freely into the largest tank of MIC. It was five past midnight then. This led to an uncontrolled reaction and spewed out a deadly white cloud of MIC, hydrogen cyanide, mono methylamine and other chemicals. Aided by the prevailing winds, the deadly cloud settled over most of Bhopal, and soon thereafter the people began to die. Incidentally, there were six safety systems designed to contain such a leak. But, none of them was operational! As a result, the gas spread throughout the city of Bhopal. Half a million people were exposed to the deadly gas. Some 8,000 died in the first three days alone.

* 20 years after Bhopal Gas tragedy – the editorial emphasises on rehabilitation of gas victims, observance of safety norms and disaster management.

The gigantic and dense poisonous cloud of MIC left thousands of children dead or permanently disabled. Seventy per cent of the children born before the disaster continue to suffer from respiratory diseases and 55 per cent from affected eyesight. After the accident, many pregnant women suffered miscarriages, while others delivered still born or malformed babies. More than half the children exposed to the gas in their mothers' wombs died. Many were born with deformities. Indeed, these children may carry forward the toxic legacy of their parents in the form of genetic disorders. Even today, lakhs of residents of Bhopal continue to be ill with complaints of diseases of the eyes, lungs, kidneys, liver, brain, reproductive and immune systems. The rate of TB among people exposed to the gas is four times higher than the national average. Amongst women exposed to the gas, the problems reported include early menopause – in some cases even in early twenties - and short and painful menstrual cycles. Since the disaster, survivors have been plagued with an epidemic of cancers, menstrual disorders and what one doctor described as "monstrous births."

Neither Union Carbide Corporation, nor Dow Chemicals, which took over Union Carbide Corporation in 2001, took responsibility for the leak. UCC, however, abided by a 1989 Supreme Court ruling asking it to pay compensation of $ 470 million after a long legal battle in the US and India. Union Carbide settled the civil suit by paying victims a lump sum of $ 470 million (about Rs. 705 crore then). The amount was arbitrarily estimated on the basis of 3,000 dead and 1 lakh injured. However, later estimates showed that about 20,000 died and over 570,000 still suffer! Till November 2003, the next–of-kin of Bhopal's dead had received Rs. 57,000 while the injured had been paid Rs. 26,000 each. Disbursement of another unutilised Rs. 1565 crore to the injured 570,000 persons began as recently as November

15 this year. This would entitle on an average Rs. 50,000 per injured person towards compensation – a pittance indeed for a people economically and physically destroyed over two generations!

Twenty years after the incident, Bhopal residents remain at risk of poisoning due to toxic material still stocked around the plant. There are signs that a second tragedy is in the making. New environmental studies indicate that tonnes of toxic material dumped at the old plant has now seeped into the groundwater, affecting a new generation of Bhopal citizens. Tests reveal cancer and brain-damaging and birth-defect causing chemicals and those causing impairment of foetal development. Mercury and lead contamination have even found their way into samples of breast milk. Ground water tests have shown contamination levels hundreds of times higher than World Health Organisation limits.

"This tragedy is living on," says Abdul Jabbar, who runs a seamstress workshop for widows of gas victims. "The groundwater for 3 to 5 kilometers from the site is contaminated, and this comes 20 years after the tragedy struck Bhopal. The state public health agency has conducted two studies proving the water is unfit for drinking, but still people use the hand pumps." Back in 1984, the wind direction carried the methyl isocyanate gas toward the south. But now, the contaminated groundwater is heading north, carrying the poisons to a completely new population – a cruel twist indeed! "Those who are living out the consequences of the tragedy, they are the only ones who remember it," says one of the 500,000 who survived that night but continues to suffer from its effects!

The Bhopal Gas Tragedy lives on – even after two decades. It calls for a concerted effort on the part of the Government and the social groups for the care of those who survived the tragedy and their rehabilitation. How do we ensure that such tragedies will not repeat in future? Strict observance of the safety norms while establishing a potentially hazardous industry, on-going studies on the environmental pollution it causes, and preparedness of people living in the immediate neighbourhood to face up to a possible disaster should it ever take place, would go a long way in avoiding such tragedies. Further, it is imperative that the hazardous plants which are already working in different parts of the country be tested periodically for safety, and people living in the neighbourhood made aware of the plant, its products and the potential threat it poses. It is also advisable to conduct mock-drills and be prepared in case a disaster does take place. Peoples' science groups and science communicators need to have disaster management high on their agenda.

(December 2004)

Tsunami Lessons*

Till a few days ago, the word ‘tsunami’ did not exist in our day-to-day vocabulary. Today it has become a household term synonymous with instant death and devastation by a violent sea. On the morning of Sunday the 26 December, 2004, when the world was still in a Christmas mood, a powerful earthquake with its epicenter under the Indian Ocean off the western coast of the Indonesian island of Sumatra shook the region. This was world’s strongest earthquake in last 40 years that recorded 9 on the Richter scale. The quake set off shock waves through the ocean – the giant tsunamis - that lashed across the coast of 13 nations, and were felt more than 6500 kilometres away on the coast of East Africa. Sumatra suffered double shock – that of the quake and the earliest strike of the tsunami. There would have been 90 to 150 minutes in which warnings could have been sounded by radio, television or even by loudspeakers in the areas most affected – Thailand, Sri Lanka, the Andaman and Nicobar chain of islands, and the eastern coast of Indian mainland. Alas! There was no established mechanism to pass warnings to the countries around the ocean’s shores. The death toll in the first 10 days was put at about 150,000 people, and continues to grow with each passing day, and ten times more rendered homeless. But, how are these tsunamis - the giant killer waves - produced?

* On 26 December 2004, a massive earthquake with its epicentre in Sumatra produced giant tsunami in the Indian Ocean that affected 13 nations and took toll of over 1.5 lakh people. The tsunami was the worst ever in recorded history.

The Earth's surface is made up of a series of large tectonic plates – or landmasses. The term 'tectonic' refers to the large scale processes that take place within the structure of the Earth's crust. These plates are made up of the crust and the upper part of a layer, called the mantle, underneath. The crust and upper mantle together constitute the lithosphere (from Greek lithos meaning stone) which is about 80 km deep formed by the giant plates that form a giant jigsaw puzzle around the globe. These plates are in constant motion travelling at a few centimetres per year. The edges of these plates, where they move against each other, are the sites of intense geologic activity, such as earthquakes and mountain formation. Surely, when the plates move, the ocean floors also move. The puzzle pieces, that is, the plates shift each year by a few centimetres as they slide on top of a somewhat fluid part of the mantle called the asthenosphere (from Greek asthenes meaning weak). The asthenosphere is ductile like putty and responds to the temperature of the Earth. It is the asthenosphere that carries the lithosphere, including the continents - and oceans - on its back.

Tsunami stands for a Japanese word that translates as harbour wave, which is triggered by a vertical disturbance in the ocean, say, an earthquake, a landslide or a volcanic eruption. The disaster on 26 December, 2004 was caused by a massive earthquake off the coast of Sumatra, where two plates of the Earth's crust – the Indian plate and the Burma plate - grind against each other. The Indian plate usually moves northeast about 6 centimetres every year – or about twice the growth of the finger-nails every year! Stress built up as the Indian plate pulled down on the Burma plate. Apparently, the two plates slid about 15 metres at once! It is estimated that about 1,200 kilometres of the Burma plate snapped and forced a massive displacement of water in the Indian Ocean. Sudden motion forced water up and down. This generated waves that spread in all directions, moving as fast as 800 km / hr. In the deep sea the waves may be imperceptible. On the surface, one may not even notice what is happening underneath. These are tsunamis! In deep water, tsunamis are very long, shallow waves. Hence they do not lose much energy and can travel vast distances until they are slowed down by resistance from the sea floor near shore, and gain height. Further, their retreat from the land can be quick – and as dangerous as its approach. Tsunamis often come in a series.

How is it that the tsunamis killed over 1.5 lakh of people across the two continents? Despite the great speed, tsunamis travel much slower than the seismic waves. Hence earthquake information is often available hours before the tsunamis are able to travel across the ocean. India has all the equipment to monitor earthquakes, but none to spot tsunamis - nor does any other country from Thailand to Somalia. Tsunamis have mainly occurred in the past in the Pacific Ocean, ringed as it is by volcanoes and earthquake zones. For the last 55 years, 26 countries around the Pacific have shared a tsunami warning centre. Those around the Indian Ocean have no such centre, the tsunami phenomenon being so rare in this region! However, in view of the high stakes involved, India is now in the process of setting up a tsunami warning centre.

But the sending out of a warning signal is not the life saving part. It is the education of the people and the response to such warnings that is crucial for saving lives. Even if we had a warning, it would have served little purpose in the absence of an established system to disseminate information to coastal communities. Organising awareness programmes/ campaigns giving scientific information would go a long way in minimizing loss of life and property. Prior mock-drills are equally important and are regularly practised in Japan – the most tsunami-prone country. Further, we need core groups that are familiar with physical and emotional needs of the victims – educational, medical, housing, relief operations and rehabilitation, working in collaboration with the village panchayats. Equally important is the development of an official interactive website giving important and latest information about the disaster and responding to the queries of the people. Ham radio activity has proved its utility time and again – even during the present disaster - by establishing an emergency communication network soon after the natural calamities, and therefore needs to be promoted. Vigyan Prasar, incidentally, has been promoting the activity in different parts of the country. Ham radio station of NCSTC/Vigyan Prasar actively participated in setting up emergency communication network with ham stations established in the affected areas, especially the Andaman and Nicobar islands.

The tsunami disaster reminds us of the disasters like the Latur and Gujarat earthquakes; and the super-cyclone in Orissa in the last decade – and our unpreparedness every time the disaster struck. Still, sky scrapers continue to rise in the reclaimed lands of Mumbai and Kolkata. Delhi is no exception. How much prepared are we to face up to a Gujarat-type earthquake should it ever take place in Mumbai or Delhi?

May be we shall never be able to fully and correctly predict a tsunami and its impact, or an earthquake. But, we cannot afford to be complacent, and must remain prepared to face any eventuality with minimum response time. These are the Tsunami Lessons.

(January 2005)

Science in Schools

One of the objectives of science education is to develop inventiveness and creativity along with competence. True, science education in India develops competence, but seldom encourages inventiveness and creativity. This is evident from the fact that Indian students perform very well in formal and scholastic tests, but few make it to the grade of outstanding researchers or original thinkers. It is certainly paradoxical that India has produced, and continues to produce, outstanding scientists, engineers, and doctors - yet science teaching in schools in India is in poor shape. An average science student in the country demonstrates neither inventiveness nor creativity. Yet there is a scramble for admission to science stream in schools - not because our bright girls and boys are genuinely interested in a scientific career, but because this is the path that leads to the gateway of the preferred career in medicine or engineering.

Children are naturally observant and curious, and love observing and exploring the world around them. Indeed this is what science is all about. Unfortunately these are the very traits suppressed by the way science is taught in our schools. Science and technology are progressing ever more rapidly. So is the ever increasing load of information in the school curricula! Science is presented as a mere collection of facts, laws and formulae, and figuring out how to apply them - a system that encourages rote learning rather than encouraging curiosity and exploration. With the growing importance of science and technology for the socioeconomic development of our country, it is imperative that the present system for teaching and learning science in schools be totally overhauled as a matter of utmost urgency.

Surely, teaching of science in schools is expected to foster the natural curiosity, encourage learning through observation, and teach the children to work with their hands, without burdening them with a rigorous curriculum and examinations. Incidentally, the issue of a heavy school bag and a heavy syllabus was addressed by the Yash Pal Committee in 1993 in a report entitled "Learning without Burden". Our science education encourages students to learn the concepts by heart but never understand them! It is imperative that they are introduced to basic scientific concepts appropriate for their age through observation and simple activities. Further, there has to be continuity and coherence in the curriculum at all stages, say, from primary to upper primary, upper primary to secondary and secondary to senior secondary levels. The science courses would need to be restructured with less curriculum load and in an imaginative manner in order that they become easily comprehensible and interesting. Despite peer pressure and intense competition, children then would not experience a high level of stress pushing them into a state of depression; or as in some cases even take the extreme step of taking their own lives.

However, could restructuring of the science courses with lesser curriculum load alone be sufficient to provide scope for joy of learning, inventiveness and creativity? It is in this context that non-formal mode of education assumes significance, wherein children could undertake investigative science projects, develop innovative models / exhibits, or just tinker around with a few simple gadgets. To provide an environment for innovation, inventiveness and creativity, it would be imperative to provide a suitable forum like science clubs at schools with minimal facilities like a few simple tools, measuring instruments, and a modest library. The activities of the clubs could range from individual projects to group projects. Indeed, a variety of innovative software and teaching / learning packages and activity kits have been developed by several Government / non-Government organizations in the country that could be made available to them. However, the teachers would need to be oriented to help children do such co-curricular activities. Science clubs could be affiliated to existing national networks of science clubs and could even play a major role in communicating science and technology to the general public. Further, the children could be encouraged to participate in activities like the National Children's Science Congress and the National Science Exhibition.

Not that there have been no conscious attempts to improve science education in schools. The National Council of Educational Research and Training (NCERT), which was set up as an autonomous organization to advise the Union and State Governments on school education policies, has played a key role in developing science curricula, syllabi and text books since the early sixties of the previous century. Till mid-seventies, a disciplinary approach for teaching of science was recommended – there were separate text books for physics, chemistry and biology. Later, science was considered as part of environmental studies at primary level, and as one composite subject at upper primary and secondary stages. In 1986, the National Policy on Education considered, for the first time, the teaching of science at secondary stage as a single subject rather than three separate disciplines. In the National Science Curriculum Framework – 2000, science and technology, rather than science alone, were introduced at upper primary and secondary stages.

NCERT is currently engaged in its periodic National Curriculum Framework Review. A review of the science education in schools has also been undertaken as part of this process to look at the ways to reform the teaching of science in schools. True, countrywide school curricular reform is a complex and difficult process since education is a subject that falls under the purview of the State Governments. The task is made even more difficult due to the fact that resistance to change is generally quite high.

There is no gainsaying the fact that better science education in schools would encourage not only competence but also inventiveness and creativity, and at the same time expose our bright children to the thrill and challenges of science. Then they will not turn away from a career in science. This would help our country transform into a nation of scientifically thinking people, equipped to make informed choices and decisions. More so in a world where stem cells, nanotechnology, genetically modified crops and Information and Communication Technology have a direct bearing on everyday life.

(April 2005)

Bridging the Divide

The Satellite Instructional Television Experiment in the mid-1970s was probably the biggest social experiment anywhere in the world that established the importance of satellite communication in the field of education in India. The widespread use of personal computers since nearly two decades ago, advances in telecommunication, Internet a decade ago, and mobile phones along with convergence of various technologies has, in the form of Information and Communication Technology (ICT), opened up new opportunities and challenges in the field of education. Indeed, the impact of Information Technology (IT) industry on the economy has been enormous. During the last year alone, IT contributed 3 per cent of India's gross domestic product (GDP).

However, the vast potential of ICT in the field of education remains largely untapped. The efforts have been piecemeal and sporadic. A beginning for introducing computers in the school system was made through the Computer Literacy and Studies in Schools (CLASS) project in the early 1980s. However, schools faced problems of infrastructure, appropriate software and lack of trained manpower. Today, the scenario has changed with large number of cyber cafes, increasing use of personal computers in schools, homes and workplaces, and internet connectivity. No doubt, ICT holds renewed promise as a powerful tool for education and development. The debate on the digital divide, however, continues unabated. Why is that? Is it that ICT has benefited haves rather than havenots? Is digital divide a problem in itself?

Indeed, the digital divide signifies more deep rooted divides of income, development and literacy. This is especially true of developing countries. There is no gainsaying the fact that fewer people in developing countries like India own computers and have access to the internet. The reasons are many – they are too poor, illiterate or have more pressing concerns like food, healthcare and security. A computer is of little use if there is no food or electricity or if one cannot read. True, there have been a few sporadic attempts to set up centres with the aid of international donor agencies and local government support to offer villagers a range of information including market prices for crop, job listings, welfare schemes of government, healthcare, etc. However, due to the more basic problems outlined above, a large section of population has remained deprived of the ICT boom in the country. Surely, centres like the M.S. Swaminathan Research Foundation in Nagpattinam have been providing information on sea wave heights, weather patterns and satellite mapping for the movements of large schools of fish in the ocean. But, it is imperative to ensure that this information does not benefit the rich alone. Conscious efforts need to be put in so that even the poor fishermen lacking motorboats and navigation equipment are also equally benefited.

How do we make rural ICTs particularly useful to the illiterate and the poor who are at the bottom of the socioeconomic ladder? An important factor – rather a deciding factor in determining whether the digital divide can ever be bridged is the cost of the technology. It is, therefore, imperative that we develop appropriate low-cost technologies that can drastically cut the cost of access to information – even if such innovations do take time and require high investment to begin with. At the same time, we cannot afford to turn Nelson's eye to the older technologies and the proven means of delivery systems like the community radio, used by several development organizations. Simple technologies like receiving information from loudspeakers or a newsletter printed and delivered around a village could form an integral part of an internet hub located in a village. Such hybrid networks may well prove to be the appropriate technologies for a country like India and the other developing countries.

A technology which has made a significant mark with regard to the information access is that of mobile phones, which do not rely on a permanent electricity supply and can be used by people who cannot read or write. In particular, the widespread use of mobile phones among the women of Bangladeshi villages, the telephone ladies, is well known. Farmers and fishermen of India have been using mobile phones to call market and work out where they can get the best prices for the produce. Small businessmen use them to shop around for supplies and even for making cashless payments. If we could make the mobile network accessible to our rural folk, we may be in a position to bridge the digital divide to a great extent, rather than trying to close the digital divide through top down IT infrastructure projects.

EduSat provides an interactive satellite-based distance education system for the country utilizing audiovisual medium, and employing Direct-To-Home (DTH) quality broadcast. With its multiple regional beams covering different parts of India and a beam covering the Indian mainland, it is possible to establish talk-back terminals for interactive programmes on science education. These would provide an interactive channel for students with experts and could include talks, lectures / demonstrations, discussions, question-answer sessions, and also can be utilised for education on natural disasters and relief operations. Talkback terminals and receive-only terminals could be set up at selected rural schools that could also be utilized by other schools in the neighborhood. Satellite Radio also can prove to be an important tool for education and development in India.

ICT as a tool should be used with care so that it serves to bridge the social divide and equalize opportunity; inappropriate and insensitive use may in fact widen the divide. Given the growing reach of the technology it is imperative that efforts are initiated to utilize ICT to face the challenges of a society that is fast transforming into information driven society.

(May 2005)

Protecting Our Ancient Wisdom and Heritage

Ayurveda, or the science of life, prevention of disease, and longevity, is probably the oldest medical system available on this planet. It is essentially based on the idea that the body, mind and the spirit are interconnected and that all three must be "balanced" to achieve the highest degree of health. The Rigveda, the oldest of the four Vedas, contains verses on the nature of health and disease, pathogenesis and principles of treatment. It also describes the use of herbs and preparations that could be used to assist an individual in overcoming various ailments of the mind and body and to foster longevity. The Atharva Veda even contains sections on internal medicine, surgery, opthamology, toxicology, psychiatry, paediatrics, gerontology, and the science of fertility. It is these verses that lie at the base of Ayurveda.

Over the millennia, Ayurveda grew into a respected and widely used system of healing in India. There were two main re-organizers of Ayurveda whose works are still existing in tact today - Charaka and Sushruta. The Charaka Samhita is the oldest of the treatises on Ayurveda and was probably first compiled around 1500 BC. It elaborates on the physiological and anatomical structure of the human body, various aetiological agents along with their role in pathogenesis, symptoms and signs of various diseases, the methodology for examination of patients, treatment, and prognosis. Sushruta is considered to be the father of surgery. In the Sushruta Samhita, the second major treatise on Ayurveda, one finds detailed descriptions of surgical instruments, classifications of fractures, wounds, abscesses, and burns as well as elaboration of procedures for plastic surgery and anal-rectal surgery. Sushruta has even described the procedure for dissection of the human body. The next important authority in Ayurveda after Charaka and Sushruta was Vagbhata (about seventh century AD). His treatise, Ashtanga Hridaya, presented a summary of Charaka and Sushruta and brought the subject up to date. He even introduced a number of new herbs and made valuable modifications and additions in surgery. Ayurveda continued to be the major system of medicine in India for several millennia, and has continued to be so even today despite the rise of modern system of medicines - allopathy in particular. It is believed that nearly eighty per cent of Indians still use Ayurveda. In the recent years, popularity of Ayurveda has significantly gone up - even in the USA. Ayurvedic remedies are now available in the USA from South Asian markets, Ayurvedic practitioners, health food stores, and even the Internet. According to an estimate, the herbal drugs industry in India is worth Rs 2,300 crore, with a global Ayurvedic products market reportedly estimated at $14.2 billion!

Occasionally, along with herbs and minerals, metals are also used in Ayurvedic herbal medical products. When such products are consumed over a long period of time, the metal content could exceed the maximum allowable limits and have an adverse effect on health. Heavy metal toxicity is most damaging to the digestive tract and the liver, and has adverse effects on the nervous system. While arsenic and mercury can cause liver failure, lead tends to affect the nerves, brain and intestines. Indeed, the problem with the metals is that even if they are taken in very small doses, they can accumulate in the body over the passage of time.

As reported in the newspapers, recently, in Delhi, a top banker’s wife was admitted to hospital after doctors detected a liver malfunction. On examining the patient's blood samples, pathologists found very high levels of heavy metals — arsenic, lead and mercury. They were told that the lady, in her 50s, had been taking Ayurvedic medicines for the past five years to treat a constipation problem. A similar incident was reported in a Boston hospital a few years ago, when a patient complained of intractable seizures. Tests showed his blood's lead level to be 89 units. Normal levels for an adult are under two units. It was later found that the India-born patient, also in his 50s, was taking an Ayurvedic medicine for arthritis. The medicine was found to have high metal levels, and he had been on the dose for over six years. Could it be, that unsafe medical products are being labelled Ayurvedic giving India's ancient system of healing a bad name?

According to a study conducted by the Harvard Medical School (the results of which were published in the December 2004 issue of the Journal of American Medical Association) revealed that one out of five Ayurvedic herbal medical products produced in South Asia and available in Boston South Asian grocery stores contained potentially harmful levels of lead, mercury, and/or arsenic. Users of Ayurvedic medicine hence could be at risk for heavy metal toxicity. Some doctors in India also have voiced similar concerns. The authors hence recommended that testing of Ayurvedic herbal medical products for toxic heavy metals be made mandatory. Of course, the health hazards posed by these products could vary significantly depending on the degree of metallic content and the constitution of the person taking it.

While allopathic drugs have to establish their efficacy and safety through trials, this is not required for Ayurvedic drugs. The remedies have only to be listed in a classical Ayurvedic text. Further, one does not require a licence to sell the Ayurvedic medicines, and so anybody can sell them!

A large number of Ayurvedic medicines are available over the counter, and require no prescription. Obviously, nobody knows how long to take them and when to stop. Many manufacturers don't bother about separation of the active ingredient in the plant. As such, the whole plant or plant part may be used in the making of the Ayurvedic tablet! Further, there are no strict regulations for labelling and packaging, requirements of inserts, and explaining side effects, if any. How do we go about it then?

There is no gainsaying the fact that we need to address the issues raised above on a war footing and protect our ancient wisdom and heritage through tighter rules. It is, however, comforting to note that the Government has initiated action in this direction.

(June 2005)

The Call of the Wild*

In 1969, a serious concern was voiced about the threat to several species of wildlife and the shrinkage of wilderness in the country at the General Assembly meeting in New Delhi of the International Union for Conservation of Nature and Natural Resources (IUCN). In 1970, a national ban on tiger hunting was imposed and in 1972 the Wildlife Protection Act came into force. In the same year, the first ever tiger census in India was conducted which revealed the existence of only 1827 tigers! The tiger population in India at the time of India's independence was estimated at about 40,000! A task force was set up to formulate a project for tiger conservation with an ecological approach. It was then that Project Tiger was launched in 1973-74 that aimed at tiger conservation in specially constituted 'tiger reserves'. Incidentally, in the initial stages, Project Tiger was a joint effort of the Government of India and World Wide Fund for Nature (WWF). Now it is a Government of India endeavour.

Various tiger reserves were created in the country under the Project Tiger on a 'core-buffer' strategy. The 'core' areas were freed from human activities and the buffer areas were subjected to 'conservation oriented land use'. Initially, 9 tiger reserves were established in different States during the period 1973-74, by pooling the resources available with the Central and State Governments. The project started as a 'Central Sector Scheme' with the full assistance of Central Government till 1979-80: later, it became a 'centrally

* In June 2005 wildlife experts revealed there has been no tiger sighting in the Sariska Wildlife Santuary since June 2004!

Sponsored Scheme' from 1980-81,with equal sharing of expenditure between the center and the states. Today, India has 27 Tiger Reserves to protect the dwindling population of tigers in different parts of the country.

Why should we be concerned so much with tiger and the tiger population? To begin with, tiger is at the apex of the food chain, and hence is the indicator of the stability of the eco-system. For example, for a tiger population to survive, a habitat should possess a good prey base, which in turn depends on undisturbed forest vegetation. This would imply the conservation of the entire eco-system and apart from tigers all other wild animals also would increase in number. The website of the Project Tiger lists the main achievements of this project as being the excellent recovery of the habitat and consequent increase in the tiger population in the reserve areas, from a mere 268 in 9 reserves in 1972 to 1576 in 27 reserves in 2003. In the entire country, however, the tiger population went up from 1827 in 1972 to 3773 in 2001-2002, when the tiger census was last conducted. Apparently, Project Tiger could be described as a huge success story as regards the conservation of the wildlife - tiger in particular. Once again the tiger could roam majestically – at least in the 27 tiger reserves.

Then, a terrible tragedy struck Sariska tiger reserve in Rajasthan, which was home to 22 tigers. By January 2005, there was not a shred of evidence of tigers there! They were all extinct. It was a crisis of magnitude never encountered before. Those who have roamed around in the jungles and seen wildlife in its natural glory only can feel the magnitude of the crisis. It is like a house whose all members have perished in a violent manner!

How did this tragedy of such a great magnitude take place? The indications are that the wipe out of tigers in

Sariska was a result of poaching. And, how were they killed? According to Valmik Thapar, a member of the Prime Minister's Tiger Task Force, and who has spent 30 years serving the tiger, the tigers were killed amid agonizing roars mainly by metal traps on the paths to waterholes or around kills, livestock and deer kills. Apparently, an organized gang of poachers had killed the tigers. There are signs of decline in the number of tigers in Ranthambore (Rajasthan) and Panna (Madhya Pradesh) reserves too. Indeed 12 out of 27 tiger reserves need immediate attention, as Thapar says. Why are the tigers killed? Tiger parts are considered an aphrodisiac by believers in traditional medicine in many parts of East Asia, including China. With a tiger body and all its parts estimated to be worth about US $ 65,000 on the Chinese medicine market, it is poachers who are destroying India's tiger population. International trade in tiger parts is banned under the United Nations' Convention on Trade in Endangered Species, but illegal trade continues to flourish in areas ranging from the Russian Far East to Indochina. Surely, more must be done to stem the tiger trade by curbing the market demand for tiger parts at the source itself.

The disappearance of the tiger from the Sariska reserve means that an important local Indian gene pool of tiger has been lost forever. Surely, we need to review our wildlife conservation policy and its implementation in the field. If the immediate corrective steps are not taken, the story is likely to be repeated in many other tiger reserves. The average age of forest guards in Sariska is reported to be 53 years. Surely, we cannot expect them to patrol a rugged hilly terrain. We need to recruit local persons who can make tough forest guards and who are familiar with the terrain. A number of sanctuaries have villages still located inside them – as is the case with Sariska and Ranthambore. There is no gainsaying the fact that for the protected areas to survive, the support of the local people must be ensured. There has to be communication between the villagers and the forest guards. Further, we must seriously involve local people in protected area management. Efforts need to be put in to undertake ecodevelopment activities around the protected areas to provide for the basic needs of people there. The help of reputed NGOs could be taken to mould the local opinion in favour of scientific wildlife management of our sanctuaries, while special education programmes could help in inspiring, informing and empowering local communities to participate in the protection of the wildlife.

The disappearance of the tiger from Sariska is a major setback to our wildlife management. May be, we could reintroduce tigers in Sariska. The prey base and habitat of Sariska are still capable of supporting a number of tigers.

Soon after reading the Sariska reports in the newspapers, I dug out my childhood treasure of Jim Corbett's - The Temple Tiger, the Man Eaters of Kumaon and so on. In those stories, it was the human beings who constantly lived in mortal fear of falling prey to tigers. Today the roles seem to have reversed! Today it is the call of the wild; tomorrow it may just be the wilderness. We have to act fast.

(July 2005)

Science Popularisation : Whose Cup of Tea is it, Anyway?

Over the years, there have been numerous initiatives and novel efforts in S&T popularisation utilizing a variety of means, methods and media. Different modes employed include development of low cost learning / teaching aids, exhibitions, jathas, radio / video programmes, folk media, publication of books etc, on topics like health, water, environment, energy, miracles / superstitions and their scientific explanation and so on. Some of the nationwide campaigns undertaken by NCSTC / VP included activities built around the Total Solar Eclipses (TSE) of 1995 and 1999, Venus Transit of 2004, Vigyan Rail during 2003-04, Year of Scientific Awareness (YSA) 2004, and the on going World Year of Physics 2005 (WYP 2005).

That NCSTC and VP have been paying due attention to the training of science communicators needs no emphasis. Care is taken that the training programmes have an emphasis not only on information and content, but also on method of science and its outlook. A conscious attempt is made to convey the thrill and excitement of science. In this regard, NCSTC and VP share a symbiotic relationship. VP produces and disseminates high quality software and resource material, identifies the venues and experts; and also works out the nitty-gritty of the training programmes. NCSTC, on its part, shoulders the responsibility of coordinating the training programmes for resource persons at zonal levels and a host of other activities and events in different States.

Recently, NCSTC and VP completed the first phase of the year-long activities in the country of the World Year of

Physics 2005 (WYP 2005). The programme envisages celebration of 100 years of Relativity and the Golden Decade 1895-1905 in which momentous discoveries were made – especially in Physics – that completely changed our perception of nature and the face of the society. The discoveries made during this period ushered in an era that we call Modern Physics. The main objective of this programme is to convey the thrill and excitement of science and inculcate scientific outlook among the people – especially children - by making them aware of the momentous discoveries made during this period and derive inspiration from the great lives and great deeds of the makers of these discoveries.

Incidentally, the first phase of the WYP 2005 consisted of five regional Training Programmes for Master Resource Persons drawn from different States. Once they return to their home States, they would train more people within their States and organize a host of activities to be coordinated by the respective State Councils / Departments of S&T. Indeed the exercise for the regional training programme started well in advance. The participants to be invited were required to possess a good academic background and a flair for communicating science to various target groups. The State S&T Councils / Departments were requested to nominate the participants accordingly. The response from the State Councils / Departments, however, started trickling in only as the date for the programme approached. A few participants complained that they received the intimation from their respective State Council / Department at eleventh hour and that they did not even know what was expected of them during the programme! Some complained that they had difficulty in getting duty leave from their institution / organization. Well, these are some of the ground realities that need to be attended to expeditiously.

The training programmes consisted of lectures / demonstrations by well known physicists who also have been acclaimed science communicators, demonstration of innovative physics experiments and an astronomy kit, Anant Yatra – a three part video programme made by VP on the Golden Decade and visits to R&D labs. Participants were also given a set of resource material – resource articles, astronomy kit, books, a CD with 9 power point presentations on discoveries made during the Golden Decade and Anant Yatra. They enjoyed sessions on demonstration of innovative physics experiments and the astronomy activity kit, but rarely interacted with the speakers during the lectures! In general the response was positive and the participants appeared to be an inspired lot, but there were a few comments and suggestions which were truly revealing. I especially remember one comment hurled at us – "If YOU want to popularize science, YOU must bring out resource material in all Indian languages – not just in Hindi and English - and distribute it free! What is more, YOU must go to villages!" Well, this feeling echoed in almost all the regional training programmes to a lesser or a greater extent organised jointly by NCSTC and VP at Shimla, Guwahati, Mumbai, Bangalore and Bhubaneswar respectively.

Whose cup of tea then is science popularization, anyway? Nodal agencies like NCSTC and VP? State S&T Councils / Departments? NGOs? Or the science communicators working in the field? Let us realize that apex bodies like NCSTC and VP can only play a catalytic role. VP can produce a variety of S&T communication software and disseminate it through NGOs and other outlets utilizing different means, media and modes – but certainly cannot distribute it free! It is here where we need a people's science movement a la Kerala Sastra Sahitya Parishad. A programme conceptualized at national level by NCSTC and / or VP could be implemented at State level only by State S&T Councils /

Departments – be it TSE, Venus Transit, YSA or WYP 2005. It is hence imperative that State S&T Councils / Departments continuously interact with NGOs active in the field of S&T communication and put in efforts to develop a core group of science communicators who could then spearhead a campaign within their State conceptualized by NCSTC / VP. Science popularization will then be our cup of tea – not just yours or mine!

(August 2005)

Nature's Fury – We Compound It Further

Floods in the months of June or July are nothing new. But, the deluge that paralysed Mumbai and left hundreds of people dead in Maharashtra was an outcome of some of the heaviest of rainfall in the recorded history of our country. The downpour affected over 20 million people. The 94.4 cm rainfall that Mumbai received on 26 July 2005 surpassed even the highest rainfall recorded at Cherrapunjee in a single day in last hundred years.

In the aftermath of deluge, large parts of India's economic capital went without power or drinking water for several days. 1500 hundred lost their lives in various parts of Maharashtra and due to various flood related diseases. In Mumbai alone, over 500 people died. Water borne diseases that followed – leptospirosis in particular - claimed over 100 lives. Mumbai's infrastructure and those in charge proved to be too inadequate and inexperienced in coping with the deluge. It was reported in the press that there was hardly any communication between the various arms of the administration. It was the gritty citizens of Mumbai who played a major role in putting the city back on rails. Was this tragedy nature's fury alone? Or did we also play a role in compounding it?

In Mumbai, the so called development has swallowed the agricultural land and the coastal plantation over the decades. Mangrove swamps, wetlands, wastelands, and salt-pans act as sponges during floods and prevent sea erosion, but they are being systematically destroyed in the name of reclamation. Even the rivers flowing through the city were converted into drains, and later their banks were reclaimed to settle the slum dwellers! This has resulted in the destruction of the natural drainage channels and the local ecology. Where would the flood waters go, anyway, but flood the city and enter the houses of the poor? It is reported that construction has already taken place on a sizeable portion of the Vasai – Virar - Nala Sopara buffer zone. A proposal for a golf course by clearing 550 acres of mangrove forests in Goregaon was cleared in 1996. Often, wetland is first declared as wasteland and then wasteland as 'No Development Zone' - or NDZ as it is called. Soon after, farm-houses or a township may show up on that land! No wonder, rampant unauthorized construction and unplanned land use in many parts of the city with little thought to the vital infrastructure like sanitation, drainage, schools and colleges, hospitals, and proper water supply have been the bane of our convoluted idea of 'development'.

Thousands were evacuated when the Yamuna threatened to spill over into Delhi recently. The city is built on the banks of the river. Over the last three decades, enormous construction activity has taken place along the river banks. We now have four power plants, several new colonies, Commonwealth Games Village and the magnificent Akshardham Temple. Only the land on which these structures stand is fine, sandy soil with a high water table. Further, the Dwarka complex has come up in the catchment area of the Najafgarh Nullha, which is a natural rainwater system. "The flow of water has now been blocked by Dwarka, and could result in flash floods" says Dhunu Roy of Hazards Centre. The Noida flyover too has channelised the Yamuna. During Monsoon, the filling up of riverbed could lead to flooding. Sarai Kale Khan Bus Terminus is located on a landfill swamp. Landfills are not safe for construction. To make buildings structurally safe, foundations have to be strong and deep. In a city already laden with several problems, are we not asking for more trouble?

Kolkata is no exception. Floods have become an annual feature in Kolkata. A new colony, Rajarhat, is coming up in the city's last surviving wetlands. Mumbai's plight could be repeated in Delhi and Kolkata too! It reminds us of the disasters like the Gujarat earthquake; and the supercyclone in Orissa in the last decade – and our unpreparedness every time the disaster strikes. Still, skyscrapers continue to rise in the reclaimed lands of Mumbai and Kolkata. Delhi is no exception. Both Mumbai and Delhi are sitting on a faultline – and hence prone to earthquakes besides floods!

How much prepared are we to face up to a Gujarat-type earthquake or a Mumbai-type flood, should it ever take place? It is clear that ecology is rarely considered when new construction is planned or approved. Building plans are sanctioned based only on architectural designs, the environment is never considered at all, laments an architect from Delhi. Even the master plans are not fully implemented. Yet another factor is the untamed urbanization due to migration from rural areas – one of the major causes of unplanned growth. This leads to more slums and loss of open spaces. Further, one needs to be careful while constructing houses in zones, which are prone to landslides. This became apparent during the recent Mumbai floods and is vital in the sub-Himalayan States that lie in the seismic zones.

A disaster management plan to deal with disasters - natural or manmade - needs to be put into place at the earliest for distribution of relief materials in time, restoration of water and electric supply, and rehabilitation of those affected. This would essentially mean evolving an effective contingency plan and mechanism in partnership with members of the community – or 'bhagidari' as it is called, organizations like NCC and NGOs. Mock drills and ham radio for setting up emergency communication network would also need to be encouraged. This would minimize the suffering of the affected people with faster relief and restoration of normalcy.

May be we shall never be able to fully and correctly predict floods. But, knowing the rain intensity in different places in the city and the amount of rain that has already fallen can help identify areas most likely to face flooding and take timely action. It is imperative that the lakes or water bodies that have fallen prey to the untamed growth are revived and ensured that the rainwater easily flows into them. Further, more attention would need to be paid to the coastal regions in view of the changing climatic pattern. We ought to treat nature with respect.

(September 2005)

High Growth Low Development*

Economic growth of a country is directly related to the national income. However, human development is much more than the rise or fall of national incomes. It is about creating an environment in which people can develop their full potential and lead productive and creative lives in accord with their needs and interests. Surely, people are the true wealth of a nation. Development is thus about expanding the choices people have thereby helping them lead lives that they value. Hence it is much more than mere economic growth. This implies helping people develop capabilities - the range of things that people can do or be in life and include capabilities for human development to lead long and healthy lives, to be knowledgeable, to have access to the resources needed for a decent standard of living and to be able to participate in the life of the community.

It was with these noble thoughts that the world's Governments signed a declaration - the Millennium Declaration - in a meeting at the United Nations at the start of the new millennium. It was a solemn pledge "to free our fellow men, women and children from the abject and dehumanizing conditions of extreme poverty". The declaration provided a vision and a shared commitment to universal human rights and social justice. It was backed by clear time-bound targets, called the "Millennium Development Goals" or MDGs. These goals included halving extreme poverty, cutting child deaths, providing all of the

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* Human Development Index (HDI) is an index used to rank countries by level of "human development". The editorial is based on *Human Development Report 2005*.

world's children with education, rolling back infectious diseases and forging a new global partnership to deliver results. The deadline agreed upon for delivery was 2015.

After five years, where do we stand today? Are the developing countries catching up with the developed ones in the areas like life expectancy, child mortality, and literacy? Well, this appeared to be so in 1980s. Not any more. Alarmingly, the rate of convergence is slowing globally as the Human Development Report (HDR) 2005 of the United Nations Development Programme points out. Between 1960 and today, life expectancy has increased by 16 years in developing countries as compared to six years in the developed countries. However, since 1990, the gap between the two has reduced only by 3 months! Child mortality rates in the sub-Saharan Africa (that is, part of the regions of Africa south of the Saharan desert) are 29 times those in rich countries today compared to 13 times in 1980! Income distribution is also getting more skewed. The world's richest 500 individuals earn more than the poorest 416 million! The richest 10 per cent account for 54 per cent of the global income, while 40 per cent of those living on $ 2 a day account for just 5 per cent of the world earning! 1 billion of the world's poorest live on only $ 1 a day. To lift them above this extreme poverty line, the estimated cost works out to $ 300 billion, or just 1.6 per cent of the income of the richest 10 per cent of the world's population. Eighteen countries, with a total population of 460 million, have in fact moved backward on the Human Development Index (HDI). Incidentally, HDI is a compendium of key indicators such as income, life expectancy, and education. 12 of these countries are in sub-Saharan Africa, and six from the former Soviet Union. While the countries in southern Africa were hurt by HIV / AIDS, the economic disruption after the collapse of the Soviet Union took its toll on countries like Tajikistan, Ukraine, and Russia.

Surely, there is little cause for celebration, says HDR 2005. There is urgent need for substantial progress in meeting the Millennium Development Goals by 2015. The Report states that for large sections of the world's population, freedom from extreme poverty will remain no more than a dream unless their governments show the political will to mobilise the resources needed for reaching the specified targets. Unless the developed countries urgently introduce policies to generate more international aid to poor countries, bring in pro-poor reforms in trade, and ensure security in conflict-ridden societies, the MDGs will be unattainable before the stipulated deadline. The report points out that aid, trade, and security are interlinked and that failure in any one area could adversely affect advances made in the other two. The report is critical about the assistance to poor countries coming from the rich ones – the aid is linked to purchase by poor countries of goods and services from donor countries! Further, what is startling is the fact that some of the richest countries are still among the least generous donors!

Where does India figure in? India has been widely heralded as a success story for globalization. Over the past two decades the country has moved into the "premier" league of world economic growth. High-technology exports are booming and India's emerging middle class consumers have become a great attraction for foreign investors. But, India is well below the average HDI value for developing countries, and is ranked only 127 among 177 countries – much below China (rank 85) and Sri Lanka (rank 93)! However, our record on human development has been less impressive than the record on global integration. The HDR 2005 states that incidence of income poverty has fallen from about 36% in the early 1990s to somewhere between 25% and 30% today. But the pick up in growth has not translated into a commensurate decline in poverty. There is further cause to worry - improvements in child and infant mortality are slowing. Some of our cities may be in the midst of a technology boom, but 1 in every 11 Indian children dies in the first five years of life and India alone accounts for 2.5 million child deaths per year - or one fifth of the global total. As the HDR 2005 notes, India may be a world leader in computer software services, but when it comes to basic immunization services for children in poor rural areas, the record is less impressive. Even lower income countries like Vietnam and Bangladesh have much lower mortality rates. Malnutrition has barely improved over the past decade and affects half the country's children.

Gender disparity is yet another aspect where our record is poor. The under-5 mortality rate is 50 per cent higher for girls than boys. This implies that 130,000 young lives are lost each year just because they are girls! Similarly, the MDG was to eliminate the gender disparity in the primary school, but we have missed this target too. Then there are regional disparities. Girls born in Kerala are five times more likely to reach their fifth birthday, twice as likely to become literate and likely to live 20 years longer than girls born in Uttar Pradesh.

How shall we translate the economic growth of our country into human development? Surely, we must realize that economic growth cannot automatically lead to an improvement in human development. We shall need to put in special efforts to end inequalities based on gender and rural-urban divide. We shall require public policies aimed explicitly at broadening the distribution of benefits from growth and global integration. The lesson the HDR 2005 holds for India is that pervasive gender inequalities, alongwith rural poverty and inequalities between states, is undermining the potential for converting growth into human development.

(October 2005)

The "First" India Science Report*

The social and economic progress of a nation depends on the state of its science and technology. It is quantitatively measured and monitored rigorously by several advanced nations on a regular basis. Even a few developing countries also bring out such reports periodically. Such an exercise can assess the impact of science and technology in the country's economy and growth, and help plan for the future. What in India we have, however, till date are the limited databases of governmental agencies and reports on studies for specific purposes.

In India, we have witnessed over the years, diverse and significant developments related to Science and Technology (S&T). However, a quantitative study of scientific and technological progress has not been done so far. The India Science Report (ISR), released recently, is an exercise in this direction. This is the result of an initiative of the Indian National Science Academy (INSA). The task of preparing the report was, however, entrusted by INSA to the National Centre for Applied Economic Research (NCAER). The report focuses on science education, human resources, and public attitude towards S&T. It is worth noting that this initiative is an important step that would help arrive at appropriate methodologies and indicators for a quantitative measurement of the different aspects of the S&T system in India. Data from an all India field study undertaken by the

* INSA (Indian National Science Academy), in association with NCAER (National Centre for Applied Economic Research) brought out India's "First" Science Report in 2005.

NCAER - the National Science Survey 2004 - formed the main basis for the results presented in the ISR. These data were supplemented with data available from other secondary sources such as the Censuses of 1981, 1991 and 2001, the household National Sample Survey of 1993-94 and 2000-01, the Department of Science and Technology, the University Grants Commission (UGC) and the Institute of Applied Manpower Research. However, significant variation in the collection of data by various agencies and even non-availability of some relevant data posed a serious problem in preparation of the ISR.

What are the significant findings of the ISR? According to the ISR, there are 48.7 million people who have done graduation and other higher degrees (excluding diplomaholders), and a fourth of them have a background of science education. Of this, 39.2 million are graduates (22.3 per cent of them are from the science stream), 9.3 million postgraduates (19.4 per cent from science) and 0.3 million doctorates (one-third from the science stream). Of the graduates who are unemployed, 22.3% have studied science. The share of post graduates with science background in the total unemployed postgraduates is significantly higher (62.8%). As regards the annual enrollment at the graduate-plus level, it has risen from 6.6 million in 1995-96 to 9.84 million in 2004.

Interestingly, the proportion of those studying science at the graduate-plus level has risen from 28.8% to 34.6% in 2004. This is rather intriguing given the dwindling interest of the youth in science today. This inference, however, could be due to the fact that data includes all institutions and all disciplines categorized as "science" under the survey, which apparently includes Computer Science and Information Technology as well. How about engineering? The proportion of those doing engineering has almost doubled from 6.0% of the population studying at the graduate plus level in 1995-96 to 11.2% in 2003-04! Indeed, engineering education shows the highest growth, from 8.2% per annum in 1995- 2000 to 21.9% in 2003-04!

ISR states that there is no decline in interest in the proportion of students who wish to study science. But, a third of the students said they did not study science as they did not feel motivated enough and another 40% said the number of students in a class were too many for them to understand what was being taught! On the other hand, half the teachers interviewed believed that more computers/ equipment were required for teaching science subjects since inadequate science training was a serious issue. Since every generation of top quality scientific manpower starts at the school level; a lot also depends on the way science is taught at school levels. Surely, this is an area where we need to focus our attention.

As regards the human resource in science and technology (HRST), ISR states that India has 52.6 million graduates, post graduates and diploma holders. If we remove 12.2 million unemployed and housewives from this category, we get a total of 40.2 million that form an S&T resource base. Those who have a diploma / graduation degree and are employed in a science and technology occupation comprising the HRST 'core' group are around 14.2 million.

ISR draws interesting inferences as regards public attitude towards S&T. Over three fourths of the public feel that S&T is important for education; and believe that S&T makes lives healthier and more comfortable. On an average, the level of knowledge the population has about the scientific concepts is very high - 57%of the people knew that the centre of the earth is hot and 86% knew that that the oxygen we breathe comes from the plants. Not surprisingly, given how women are blamed for not having a male child, just 38% knew that the sex of the child depends upon the father. Surely, the answers to science related questions tend to be increasingly correct as the education levels of the respondents rise.

What are the sources of information of the public? Television remains the primary source for 57% of the people of the country, and is almost five times more popular than the newspapers. Close to three-fourths of urban households rely on TV for information, as do half the rural households. Indeed, even educated people rely more on TV than on any other medium. In the case of postgraduates, 65% rely on TV as the primary source of information compared to just 27% on newspapers. Close to two-thirds of the population gets its science related information from TV as compared to 8% from newspapers. Over three-fourths of the people (85%) have a great deal of confidence in the authenticity of the TV, and ironically it is the illiterate that have the least confidence (64%). Nearly 65% of S&T news is got from TV in India, as compared to 7% in the US. The report finds that television is the most popular source of information for most people. But this also calls for a conscious action on the part of all concerned to generate quality S&T programmes for television. Quality S&T TV programmes are few and far between. There is no gainsaying the fact that this source of dissemination of scientific information needs to be exploited fully. This finding makes a strong case to utilize television and the Edusat infrastructure for S&T communication.

How about Internet as a source of information? Internet, however, does not appear to be popular source of information in India. Over 44% of S&T information in the US is got from the Internet as compared to 0.2 % in India at present! There is a need to ensure greater penetrability of

Internet and other ICT tools at the school level as also in rural and remote areas so that access to reliable and updated information is considerably improved.

The findings ISR indicate that the initial urge to study science cuts across all sections of the society. However, for the sections in the lower socio-economic stratum, this does not often translate into fact at later stages due to several factors such as lack of affordability, lack of infrastructure; and paucity of information about scope and future opportunities. The report found that those in rural areas tend to go in more for arts than those living in urban areas - may be due to a paucity of trained science teachers in rural areas. This issue needs to be urgently addressed and appropriate measures taken to improve the situation.

Meaningful policies cannot be formulated in the absence of authentic data. Therefore, the necessity of collecting, collating, and analyzing reliable data to arrive at meaningful conclusions cannot be overemphasized. ISR has been the first such attempt in this direction. However, much still needs to be done. There are several critical areas of national importance that have not been objectively addressed in the ISR due to incomplete and / or outdated data, or even due to non-existence of reliable data / information in a few cases. But, as the authors of the report say, "The ISR is an ambitious project that is not an event but a process, of which the first report is only a beginning."

(November 2005)

Bird Flu: Scare on Wings*

There does not seem to be a respite from calamities like tsunami, cyclones, floods, tidal waves, and earthquakes – even terrorism. They have brought with them poignant stories of devastation, of death, suffering and misery. They also brought with them stories of outrage at lack of preparedness to cope with these disasters. We are now faced with yet another threat, this time from the winged members of our biosphere - the birds. Migratory birds from colder reaches have already started descending on the tropical lands during their annual sojourn, including India. It is a pleasing sight to watch a flock of migratory birds flying over the horizon. But, may be they are carrying a virus - the lethal strain H5N1 of influenza - that might soon kill millions of people!

How is it that the flu (also called influenza) virus found in the birds could prove to be so dangerous to human beings? Flu pandemics spread when one of the many influenza strains that circulate in wild and domestic birds evolves into a form that infects humans as well. This virus then adapts further and can even exchange genes with a flu strain native to humans. This chain of events produces a novel germ that is highly contagious among human beings. Flu pandemics emerge unpredictably 3-4 times a century - that is almost every generation! The last three pandemics struck in 1918, 1957 and 1968.

Indeed, the influenza pandemic in 1918 (caused by the strain H1N1) killed nearly 40 million people worldwide! The

* The outbreak of Avian Influenza Virus, capable of infecting humans, caused death of millions of poultry during 2005.

pandemic in 1957 (strain H2N1) killed 1-4 million worldwide, while the one in 1968 (strain H3N2) killed I million. What makes influenza so dangerous? After an incubation period of just about two days, influenza virus affects primarily the upper respiratory tract and airways with body temperature rising to about 104 0 F for 4-5 days. Influenza lowers the body's resistance to infections. Hence the patient may become vulnerable to infections by other organisms that could cause secondary infections of lungs, say pneumonia. Indeed, secondary pneumonia is the major cause of death related to influenza.

True, there is a genuine fear over the bird-flu spreading in Asia and Europe. However, at present the disease tends to make birds sick and rarely humans. The particular strain of bird flu – called H5N1 – currently circulating apparently originated in South Korea in 2003. So far, there have been just 64 confirmed human deaths from bird-flu. But, if the virus were to turn into something that humans could easily transmit to one another, it could cause widespread death and economic loss of billions of Rupees. It is, therefore, important to bring the H5N1 strain of bird-flu under control. It is estimated that wild life is a reservoir that harbours nearly half of the pathogens that could jump from birds or animals to humans. Situation in which wild and domestic animals, birds and human beings mingle in unhygienic conditions could provide an ideal passage for a virus to jump from one species to another. A densely packed, mixed animal market could aggravate the situation. There is no reason why bird-flu virus cannot jump to humans under such conditions causing a pandemic.

What is causing the emergence and re-emergence of different viruses? A major reason is the change that is taking place when humans travel, or the change that takes place in land use, environment or agriculture. The world is changing very fast in ways that matter to pathogens and ways that give them new opportunities to infect new host species or get to new areas. Remember SARS (severe acute respiratory syndrome), a viral respiratory illness that apparently "jumped" from animals to humans and claimed 800 lives in 2003 in about two-dozen countries? Its fast spread was attributed to the widespread international travel. Factors like urbanization, over-crowding of humans in poor tropical countries like India and other developing countries, and movement and trade of birds and animals also are equally responsible for emergence and re-emergence of these viruses.

The bird-flu virus H5N1 is only one of the1400 pathogens that have been discovered till date affecting humans. Some 13% of these are regarded as emerging that are responsible for SARS or HIV, or re-emerging that are responsible for tuberculosis or malaria. However, what is worrying is the fact that the number of new pathogens emerging seems to be growing. The current research shows that human pathogens have emerged or re-emerged 409 times in the past 50 years. What is important is the fact that a large number of diseases come from animals and birds.

How could we reduce a possible threat of bird-flu pandemic, then? Closer monitoring of poultry stocks and steps to eradicate any avian influenza outbreak could prove to be quite cost-effective. Till date, millions of birds have caught the disease and 150 million poultry have been culled. Despite this action, the virus is now endemic in Indonesia, Vietnam, Cambodia, China, Thailand, and possibly Laos. Surely, improvements in surveillance of the viral strain, veterinary health care and laboratory services could go a long way in reducing this threat.

Unfortunately, our defences today are extremely weak to face up to the possible H5N1 pandemic, should it strike.

We probably have had a good vaccine for H5N1 for more than a year. Yet it has not been properly tested till now. Nor is the best drug, Tamiflu, being stocked by governments of various countries as fast as they could, partly because the patent holder, Swiss-based Roche, till recently refused to let anyone else make it. This despite the fact that Roche could not have fulfilled the orders even of rich countries till 2007! The Indian company Cipla says that it will begin marketing the generic version of the drug by December 2005 and make a million 10-capsule courses of treatment per month by July 2006.

Unlike in the past, probably it is for the first time that we can "see" a flu pandemic on the horizon. Indeed we are much better placed today compared to the earlier pandemics - we have several tools to minimize its impact if it does arrive. Even if the dreaded H5N1 virus does not evolve into a form that can spread easily among the people, some other flu virus certainly will. The stronger our defences, the better we shall be able to face up to the challenge. We cannot afford to be complacent any more.

(December 2005)

Are We Losing the Battle Against Bacteria?

At sometime or another, almost every one of us has used an antibiotic – for a bad cut, pneumonia, or some other type of infection. Antibiotics are chemicals, which when introduced into our body, stop the growth of certain kinds of germs, called bacteria, and help our body fight disease. Indeed, human beings have been using antibiotics for over 3,000 years. The Chinese and the Egyptians stumbled over the discovery that some moulds could be used as a cure to treat rashes and wounds. Sumerians used beer soup mixed with snake skins and turtle shells. Indians and Greeks used many herbs to heal several ailments. All of these natural treatments contained some sort of antibiotic. With passage of time, people began to gain some insight of disease. In the 1860's Louis Pasteur showed that many diseases were caused by bacteria. He later recognized that one type of bacteria could be used to kill another type of bacteria.

In 1929, Sir Alexander Fleming, a Scottish bacteriologist, made the real breakthrough in antibiotics. He went on a vacation and left a petri dish of staphylococci bacteria uncovered. When he returned, he noticed that there was mould growing on it. Upon further examination, he saw that the area around the mould had no bacteria growing, thanks to a chemical produced by the mould. The name of the mould was penicillium, and hence the chemical produced by the mould was named penicillin - the first ever substance recognized as an antibiotic. Penicillin had proven that it worked against pneumonia, scarlet fever, and several other diseases; however, it had no effect on germs that caused typhoid, influenza, and many other diseases. As a result, scientists had to continue their search for other antibiotics.

After penicillin came the invention of the sulfa drug. It came from Prontosil, which is a substance used as a dye. When introduced into the body, Prontosil changes into an active germ-killing drug called sulfonamide. This drug could cure pneumonia, scarlet fever, and blood poisoning. In the late 1940's through the early 1950's, streptomycin (used in treatment of tuberculosis, typhoid fever and other infections), chloramphenicol (used in the treatment of typhoid fever, some form of meningitis and as drops or ointments for skin, eye, or ear infections), and tetracycline (prescribed to treat urinary infections, pneumonia, diseases such as typhus, sexually transmitted infections and conjunctivitis caused by the "chlamydia" bacteria) were discovered and introduced as antibiotics. However, it is interesting to note that almost immediately after penicillin was introduced, resistance in certain strains of staphylococci was noticed. By 1950's it was apparent that tuberculosis bacterium was rapidly developing resistance to streptomycin, which had commonly been used to treat it. In 1953, during a Shigella outbreak in Japan, a certain strain of dysentery bacillus was found to be resistant to chloramphenicol, tetracycline, streptomycin, and the sulfonamides.

As early as 1945, in an interview with The New York Times, Fleming warned that the misuse of penicillin could lead to selection of resistant forms of bacteria. Fleming had experimentally derived such strains by varying the dosage and conditions upon which he added the antibiotic to bacterial cultures. As a result, Fleming warned that the drug carried a large potential for misuse, especially with patients taking it orally at home, and that inadequate treatments would likely lead to mutant forms. How prophetic his words have proved!

The indiscriminate and improper use of antibiotics results in a survival-of-the-fittest selection process for bacteria, which can both inherit and acquire resistance to drugs, through mutation or by sharing DNA. This is just as in normal Darwinian evolution but accelerated umpteen times by the division of millions of microbes (microbe is an umbrella term for microscopic organisms that include bacteria, fungi and viruses). An infection treated with the wrong drug or for too short a time results in most bacteria being killed while the resistant ones survive to multiply. Antibiotics taken for viral infections, against which they are impotent, promote the growth and spread of resistant microbes in patients, their families, and the community. The lack of effective monitoring and enforcement of controls on the sale and use of antibiotics is cited by the World Health Organization (WHO) as one of the main causes of growing resistance of the world's microbes to antimicrobial drugs.

When first discovered, antibiotics were thought to be a miracle cure and they literally were. Infections that were fatal were reduced to mere inconveniences. In the early years, new antibiotics were developed faster than bacteria developed resistance to them. But the bugs caught up fast. In the 1950s and 60s, many new classes of antibiotics were discovered. But in the 1980s and 1990s, scientists could only manage to make improvements within classes. Today, some low-grade hospital bugs have become resistant to most antibiotics. Hospitals are not the only breeding grounds for these "superbugs", as they have come to be known. A marked rise in drug-resistant bugs has been observed in community homes and other places which are home to vulnerable groups of people. Worldwide, a new drug-resistant strain of tuberculosis is causing concern, particularly as the disease is enjoying resurgence. Even if resistance to some antibiotics does not prevent treatment because others are available, it still costs a large sum of money. Alternative drugs are more expensive and have greater side effects.

This emergence of resistant forms of bacteria, lacking sensitivity to once reliable antibiotics, signifies that variants untreatable by every known antibiotic are on their way and have thus moved one step closer to becoming unstoppable killers. The misuse, over-prescription and abuse of antibiotics have allowed resistant strains of bacteria to develop and once again threaten health and life. What is more, this practice may even kill those bacteria which are harmless and useful to us. With passage of time, bacteria defy not only single but multiple antibiotics and therefore become extremely difficult to control. WHO, in one of its reports has said that if nothing is done in this decade to tackle the problem, the window of opportunity may be closed for ever! Why is it that there is increasing resistance to antimicrobial therapies? In the developed world it is overuse of drugs and in the developing world it is their underuse! As a result, bacteria that were virtually eliminated with the introduction of antibiotics are mutating, gaining strength and resisting treatment. In the early 1990's Indian microbiologists had attributed outbreaks of Salmonella typhi, resistant to many drugs, to the widespread abuse of antibiotics. About 10 per cent of tuberculosis (TB) patients today have strains resistant to the most powerful antibiotics. Penicillin has become virtually useless for treating gonnorrhoea. In developed countries, up to 60 per cent of hospital acquired infections are caused by drug-resistant microbes. The economic impact of drug resistance is enormous. It costs 100 times more to treat a patient with drug-resistant TB than one with normal TB.

A possible weapon for outwitting the resistant bacteria would of course be to develop altogether new types of antibiotics that may stop bacteria from multiplying by halting production of proteins vital to their growth early in their life cycle. There is also new hope from the analyses of bacterial genomic sequences that has shown that there could be several novel targets on the bacteria for attack by antibiotics. It is possible that the development of newer class of antibiotics may kill bacteria by binding to these newly discovered bacterial targets.

What could we do to reverse the growth of the resistant bacteria, then? True, antibiotics should be used only when they are truly needed and that too only under the supervision of a physician. Further, it is essential to complete the full course of antibiotic therapy to ensure that all the pathogenic bacteria are killed. Also one must not skip doses since this causes the level of antibiotic in the blood to drop and hence giving a chance to some to survive and develop resistance to this drug. Often, physicians prescribe antibiotics even when they are not required. Often, people "demand" antibiotics from their physicians or purchase from their friendly pharmacist over the counter – without any prescription – even for colds and other viral infections. This practice must be stopped since antibiotics have no effect on viruses. One should also consider seeking non-antibiotic therapies for minor ailments. Indeed, approximately one third to one half of all antibiotic prescriptions are not even needed. Indeed, the amount of resistant bacteria people acquire from food is quite significant; hence it is advisable to wash raw fruits and vegetables thoroughly. Washing hands frequently with regular soap and warm water is the best way to avoid spreading harmful microbes.

We have been waging a fierce battle against microbes for over a century. But, eventually it is the microbe that seems to be gaining the upper hand – for which we are largely responsible. To contain this scourge, we need to formulate stricter national control policies, strict control on administration of drugs, antiseptic conditions in the hospitals and clean environment. But, the most important is the education of the people to prevent rampant and indiscriminate use of antibiotics. This is a challenge for the science communicators to spread awareness to prevent misuse and abuse of antibiotics among the people.

(February 2006)

The Virus Has Finally Landed

Bird flu first appeared in Hong Kong in 1997 and ever since, the disease has become endemic in the poultry flocks of much of Asia - Indonesia, Vietnam, Cambodia, China, and Thailand. But after January 2006, it appeared in a seemingly alarming number of new countries. Although the arrival of bird flu in Europe and its neighborhood has caused panic, yet the cases were only in wild birds. The virus was infecting chicken and humans in northern Iraq early this year. It has now been discovered in Africa - in Nigeria and Egypt; and most recently in India, and is widely distributed across poultry flocks. The immediate issue is – how did the bird flu come to these countries, and India in particular?

Migratory birds are often blamed for spreading virus. The reason for this perception to grow is that H5N1 viral strains responsible for recent outbreaks including Nigeria have been found to be very similar to the one found in Qinghai Lake in western China - where large numbers of wild water birds perished between April and June 2005 after being infected by the virus. Apparently, some species of migratory water birds may be carrying the H5N1 in its most pathogenic form and introducing it to new areas along their route. But, bird migrations in India were over around November 2005. If migratory birds had brought the virus, the H5N1 outbreaks should have taken place much before than what was observed. Further, such outbreaks should have occurred at places further north where the birds would have reached much earlier. The wild birds would by now be preparing for their return journey. It is further significant that no suspicious illness was observed by the monitoring teams of the Bombay Natural History Society among those wild birds.

Another possibility is that the humans themselves are responsible for the spread of infection in poultry. It is suggested that there are three likely transmission routes for H5N1 – commercial trade and movement of poultry, trade in wild birds, and the use of infected poultry manure as agricultural fertilizer. Most outbreaks in South-East Asia could be linked to movements of poultry and poultry products, or infected material from poultry farms, such as mud on vehicles or even people's shoes. Live animal markets also could play an important role in the spread of H5N1 virus. Indeed, such markets were the source of the first known outbreak in Hong Kong in 1997.

Ever since the test reports of the affected poultry were confirmed as positive for H5N1 strain of avian influenza, around 2.3 lakh fowls were culled in and around Navapur, Nandurbar District of Maharashtra and about a lakh in Uchchhal town of Surat District, Gujarat. Egg and chicken dishes have but disappeared from airlines, hotels, and household menus. The stakes cannot be higher. With an estimated number of 50 crore poultry, the size of the poultry industry in India is estimated at Rs. 35,000 crores. The loss incurred by poultry farms in Navapur alone is calculated at Rs. 30 crore with over 5,000 losing their livelihood.

How is it that bird flu had already assumed the proportions of an epidemic when it was reported in India? From one poultry farm nearly three decades ago, the number of poultry farms, at the last count, had grown to 58 within a radius of 3 kilometers of Navapur Nagarpalika, with proximity to markets in Gujarat and Mumbai. Today, practically every second household in Navapur is linked to poultry business. It all started with hundreds of birds dying in coops (that is, cage or pen for confining poultry) on a single day. By mid-January 2006, a leading poultry farm had been nearly wiped out, with over 50,000 birds dying in a matter of days! Poultry farm owners were convinced that the birds died most likely of a more virulent form of Ranikhet disease, which usually occurs at the onset of summer. It is estimated that nearly two lakh birds died from 15 January to 10 February! The farmers hid the information fearing loss and sent birds from affected farms to markets. The first reports of large-scale deaths appeared on 8 February and soon after the samples were sent to the High Security Animal Disease Laboratory at Bhopal, the national facility entrusted with the detection of avian influenza in birds. The H5N1 virus invasion of India was officially announced on 18 February 2006.

Humans can contract bird flu if they come in close contact with faeces or saliva of the infected chickens. It can spread by movement of live birds from farm to farm, through people wearing contaminated clothes, contaminated vehicles, equipment, feed and cages. Infected humans will have high fever, cold, running nose and difficulty in breathing. Though there are no commercially available vaccines to protect humans against H5N1; they are still in developmental stages. The next alternative is antivirals like Tamiflu. But for Tamiflu to be effective, it should be taken no more than two days after the onset of symptoms. But, Tamiflu resistant H5N1 also has been seen in Asia! Fortunately no case of avian influenza was detected in human beings at Nandurbar. Although H5N1 cannot be transferred from one individual to another, but a time may come when a person suffering from human flu can simultaneously contract bird flu, allowing the viruses to swap genetic material. The hybrid then could become communicable to others, resulting into a pandemic. What precautions could one take? Cooking at 70 degrees Celsius or above kills the virus, but refrigeration does not. Raw or partially cooked eggs should be avoided. Virus is sensitive to detergents, bleach and alcohol. Dead or culled birds should be packed in plastic bags and buried and area should be disinfected with lime and phenyl.

It is necessary to urgently address the issue of rehabilitating the poultry units affected by the cull and formulating a welfare package for poultry workers left jobless. This would improve the chances of future outbreaks being reported promptly. There is also a need to establish a National Centre for Biosecurity which could act as a nodal agency for early warning and timely action to counter biological threats to agriculture, animal husbandry and fisheries along the lines suggested by the National Commission on Farmers headed by Professor M. S. Swaminathan. Animal husbandry authorities, jointly with Krishi Vigyan Kendras, and NGOs need to initiate special campaigns to educate the poultry farmers on maintaining healthy and hygienic conditions at the farms and possible outbreak and control of various poultry diseases. This would help us root H5N1 out of India. Here is yet another challenge to science communicators and activists.

(March 2006)

Myths and Media

March 29, 2006 was a memorable day. On that day, a total eclipse of the Sun was observed from within a narrow corridor that traversed half the Earth. The path of the Moon's umbral shadow began in Brazil and extended across the Atlantic, northern Africa, and central Asia, where it ended at sunset in northern Mongolia. A partial eclipse was seen within the much broader path of the Moon's penumbral shadow that included the northern two thirds of Africa, Europe, and Asia, including India. As it happens during every total solar eclipse, a large number of expeditions from all over the world were organised to the belt of totality – including a few from India – to carry out a variety of scientific experiments to understand the structure of the solar corona and related phenomena.

Despite the fact that a partial eclipse of the Sun is far from being a spectacular event like the total solar eclipse, hordes of curious children – many accompanied by their parents – thronged planetaria and schools where special arrangements were made for safe observation of the eclipse. What was most gratifying to watch was the sparkle in their eyes and the smile on their face after they had a look at the eclipsed Sun either through a telescope or through a safe solar filter.

But, many preferred to watch the eclipse in the safest manner – on their television sets in the cool comfort of their homes. With nearly twenty news channels available on the cable network, it was expected that there would be several educative and informative programmes on the television dealing with the scientific aspects of this awesome celestial phenomenon and interviews with scientists alongwith the live coverage of the eclipse. Alas! On most of the channels, the science got eclipsed and the myths prevailed!

Often I receive calls from television channels for live interviews on such special events. This time too I received a frantic call from one channel. I was to be in a live conversation for half an hour with an anchor. When I entered the studio, I discovered that I was not the only one invited. There was an astrologer already present! The pretty and petite anchor began conversation with the astrologer. At the outset the astrologer gave an interesting piece of information that this was the first day of the Vikram Samvat. The new year thus began with an eclipse and would also end with an eclipse – which does not augur well for the human beings! In particular, since the eclipse is taking place in the *Meena Rashi* (zodiacal sign Pisces), those who were born with this zodiacal sign may face the wrath of the evil forces. Then it was my turn. I was asked to explain how the eclipses took place and where this particular eclipse would be seen in the world. Later, the scene abruptly shifted to *Brahma Sarovar* at Kurukshetra where thousands were taking a holy dip to ward off the evil effects of the eclipse. The reporter there gave a running commentary of the rituals for nearly ten minutes! For about a minute the scene then shifted to Nehru Planetarium at New Delhi, and then once again to the astrologer in the studio. He talked at length about the rituals and ceremonies that must be performed before and after the eclipse with a special caution to pregnant women not to watch the eclipse at any cost, otherwise they may give birth to physically deformed or mentally retarded children! With this piece of profound advice from the astrologer the programme ended! I was never asked to give any further information – not even about safely observing the eclipse! I might have spoken for less than two minutes! The astrologer, obviously a VIP with that channel, continued to feature for the whole day, I was told!

I believe what I have described here is what we normally witness on any such occasion. I remember yet another instance. When the rare event of Venus Transit took place on 08 June 2004, almost all television channels were flooded with astrologers spreading myths and superstitions! The only scientific programme that was telecast was on Doordarshan by Vigyan Prasar. Why do the television channels vie with each other in spreading myths and superstitions? Is it because the myths and superstitions sell? Or is it just a survival tactics in the fierce war of channel supremacy? Perhaps yes. But, media are expected to be a mirror in which the true image of the society is reflected – without any distortion. In addition, they are also expected to raise issues that ail the society, suggest ways and means to address them rationally based on facts and figures. In fact their major responsibility is to build up an opinion through a scientific approach enabling people to make informed choices.

Vigyan Prasar and Development and Educational Communication Unit of ISRO have launched a massive campaign to enhance scientific content on television with emphasis on scientific method through various Doordarshan channels. We have been receiving overwhelming response to our efforts from all corners of the country. It is nearly twenty five years since we began concerted efforts in our country to communicate science and inculcate scientific attitude among the people. Indeed, our efforts have just begun to show signs of success. Still I often I feel we are like Abhimanyu fighting a valiant but losing battle against the mighty Kaurava Generals – the umpteen television channels that continue to spread myths and superstitions!

Television is undoubtedly the most powerful medium of all – in fact a double-edged sword – that can, if used judiciously, transform the people into rationally thinking individuals, or throw them into an infinite abyss of superstitions and unscientific beliefs. There is no gainsaying the fact that the media need to refrain from feeding the public with the opium of superstitions and unscientific beliefs. Instead they should question such beliefs and offer scientific explanations. Then science would not get eclipsed, nor would the myths prevail. The media would then become a veritable tool to transform our country into a nation of scientifically thinking people.

(April 2006)

Evolution – Can It Run Backwards?

The term evolution refers both to fact and theory. When used to describe a fact, it may refer to the observations on one species of organisms changing into another species over a period of time. When used to describe a theory, it refers to an explanation about how and why the process of evolution takes place. The theory of evolution incorporates both Darwin's theory of natural selection and Mendel's principles of genetics.

Natural selection implies greater reproductive success among particular members of a species which arises from genetically determined characteristics. Such characteristics confer an advantage in a particular environment. When one species evolves into another, genetic mutations (changes) take place that are inherited by the new species. A mutation is any change in the DNA base sequence (genetic information) of a gene. Some of these mutations are more likely to spread and persist in a gene pool (species) than others. If such mutations result in a survival advantage for organisms that possess them, then they are more likely to spread and persist. However, if such mutations do not result in a survival advantage, or if they result in a survival disadvantage, they are less likely to spread and persist – they would rather perish and become extinct. Genetic mutation is random, but natural selection is not. Natural selection tests the combination of genes represented in the members of a species and allows proliferation of those that confer the greatest ability to survive and reproduce.

Evolution by natural selection is a continuing process – it operates even today. Consider the continual evolution of human pathogens. Today they pose one of the most serious public health problems facing human societies. As a result of natural selection, many strains of bacteria have become increasingly resistant to once effective antibiotics. They have amplified resistant strains which arose through naturally occurring genetic variation. For example, the microorganisms that cause malaria, tuberculosis and many other diseases have over the years developed a highly increased resistance to antibiotics and drugs which were used to treat them in the past. Continued use and overuse of these antibiotics has given these strains an advantage over non-resistant strains thereby allowing the resistant populations to proliferate. Similarly, many hundreds of insect species and other agricultural pests have evolved resistance to the pesticides used to combat them.

Textbooks define “species” as a group of organisms that can potentially breed with each other to produce fertile offspring and cannot breed with the members of other such groups. The creation of a new species from a pre-existing species – “speciation” as it is called - generally requires thousands of years. Hence, in our entire lifetime we can witness only a tiny part of the speciation process.

How is it possible for one species to give rise to more than one subsequent species? One process by which this can occur is through the division of a population into two or more smaller populations by a geographical barrier. If the environments of the respective populations differ, different traits will be selected for in each, and the evolution of these populations will follow different courses. As the two groups become isolated from each other, they would stop sharing genes, and eventually genetic differences would increase until members of the groups can no longer interbreed. At this point, they have become separate species and the speciation is complete. Through time, these two species might give rise to new species, and so on through millennia. Another process that may give rise to speciation is climate change. When climate changes, species try to follow the climate they are adapted for. Hence, they move around the landscape to stay in the same climate space. When they do that, some populations that are left behind might get isolated enough to spur morphological (physical) or genetic changes. One may get a species or population trapped in a region where climate is changing, which would induce a selective force to make them change or become extinct.

Can two species that have evolved from one species collapse into one once again? In other words, can evolution run backwards? Two fledgling species can become different enough genetically so that they can no longer hybridize effectively. But, if the barriers to gene flow come down too soon the two may hybridize and merge again. A recent issue of *New Scientist* (20 May 2006) describes two studies that point to such a possibility. One study relates to two finch (a small seed-eating songbird) species on the Santa Cruz Island (off the coast of California) – one with large bills and one with small bills – but rarely medium sized ones. This feature reflects two populations specializing in eating two different sizes of seeds. This was in 1960. Four decades later the researchers found that only birds living in sparsely settled parts of the island still showed two different bill sizes. Near the island's only town, birds with middle-sized bills had become more common! The earlier two distinct groups had collapsed into one! What could be the reason for the change? The researchers attribute this to the fact that people are providing bird feeders filled with rice and hence it is no longer a disadvantage to have an intermediate beak! Apparently everybody can eat this rice! Is the impact of human beings on environment forcing evolution into reverse?

Another study relates to *Homo sapiens* – human beings! It is really asking who we are and where we came from! True, humans did not evolve from modern apes, but humans and modern apes shared a common ancestor, a species that no longer exists. In other words, we are cousins. Evolution is not a ladder. It is a branching bush. Because we shared a recent common ancestor with chimpanzees and gorillas, we have many anatomical, genetic, biochemical, and even behavioral similarities with the African great apes. We are less similar to the Asian apes—orangutans and gibbons—and even less similar to monkeys, because we shared common ancestors with these groups in the more distant past. In this study, genomes of humans, chimps and gorillas were compared using a "molecular clock" to estimate how long ago the three groups diverged. The further back two species diverged, the more differences would have accumulated between their genome sequences. The study suggests that the two lineages split over 6.3 million years ago. But later both the species re-hybridized in a "reverse speciation" event! Complete speciation between humans and chimpanzees took place less than 6.3 million years. Natural selection then favoured those hybrid individuals whose chromosomes carried fewest of the genes that lower fertility! Evolution just selected what worked! May be, hybridization between the two fledgling species might have provided traits that saved our ancestors from extinction!

The growing genomic information should bring us closer to the understanding of the key steps in evolution – the origin of species. Surely every bit of biodiversity is invaluable. We never know which one would trigger the next innovation.

(June 2006)

In Search of Pleasure – From Caffeine to Cocaine

The consumption of drugs for recreation and pleasure is deeply rooted in our culture and history. There are numerous references to the use of wine *(sura* and *soma)* and opium *(ahiphena* or *aphena)* ever since the Vedic times. In the Mahabharata, there are several allusions to consumption of alcohol. Sushruta has listed several hundreds of plant drugs including anaesthetics, poisons, spices, and narcotics. Consumption of alcohol over dinner parties does not raise any eyebrows now-a-days. Alcohol is a simple molecule, but a complex drug. Alcohol is used in many medicinal preparations and may be a welcome antidote to stress. It may give rise to pleasurable feelings, but it also acts as a depressant. Yet another reference to a recreation drug we come across in ancient literature is the notorious plant of opium poppy. Opium is the reddish-brown heavily scented addictive drug prepared from the dried juice of unripe pods of the poppy flower, which is used in medicine as an analgesic and a narcotic. While morphine is derived from this plant, heroin is a synthetic derivative of morphine. Heroin can be smoked, snorted or dissolved in water and injected. Over time the desired effects reduce so users have to take more to have the same effect. Heroin users are generally pitied – it is assumed that they must have an addiction problem.

Most of us take caffeine in the morning coffee or tea – the cuppa that cheers and stimulates, and there is no social stigma attached to it. Indeed, caffeine is the most widely consumed stimulant, the most popular, and the safest of the recreational drugs. It is the main ingredient of tea, coffee, and chocolate, and is found in over 100 plant species. Coffee contains 100 milligrams of caffeine per average cup – about twice as much as a cup of tea. A small chocolate bar contains as much stimulant as a cup of tea. It is interesting to note that the average half-life of caffeine in the body is about 5-6 hours. This is why some of us experience a sleepless night if we take coffee after dinner. Caffeine may increase heart rate, and produce palpitations, and hence could cause needless anxiety. It may be interesting to note that extracts of the caffeine containing nuts *Cola acuminata* and *Cola nitida* are the active ingredients of the popular soft drinks Coca Cola and Pepsi.

Cocaine is a more powerful stimulant than caffeine – but not so benign. Cocaine is an extract of coca plant. Like caffeine, cocaine also has been in use for centuries. The German chemist Albert Niemann synthesized pure cocaine in 1860 and it was initially used as an anaesthetic. Cocaine is a potent central nervous system stimulant and makes the user feel euphoric and energetic. Gradually the user becomes more and more dependent on the drug. Common health effects of chronic use include heart attack, respiratory failure, stroke, and seizures. Cocaine is a strong addictive drug, the variations of which can be chewed, snorted, injected or smoked. 'Crack' is cocaine processed for smoking.

Coca Cola when first introduced in 1886 originally contained cocaine. But soon after the addictive properties of cocaine were realized in the early 20th century, it was removed from the drink and replaced with more caffeine. Sigmund Freud, the fountainhead of psychoanalysis, was an early user and extoller of the virtues of cocaine! Robert Louis Stevenson is said to have written *Dr. Jekyll and Mr. Hyde* in six days and nights on a cocaine binge! Incidentally, Peru is the largest producer of coca paste and leaf, while Colombia is the largest producer of the finished product – cocaine.

Amphetamines (also known as 'speed') are chemically made stimulant drugs. Their short-term effects include feeling of mental stimulation, emotional warmth, and increased physical energy. Amphetamines were issued to combat troops in World War II to keep them fighting in the absence of food. Amphetamines can be sniffed through a narrow tube, but can be prepared for injection, swallowed in a drink, or smoked with tobacco. Heavy use of amphetamines can cause a mental illness called psychosis where people report seeing, feeling or hearing things that are not really there, and can also induce suicidal tendencies. Rush of a stimulant is generally followed by a crash into depression.

Among the most widely used psychedelic drugs are cannabis, Ecstacy, and LSD (lysergic acid diethylamide). Their use has been on the rise in the party circuits, especially in the age group 25-35 years despite legal restrictions. Psychedelics produce hallucinations. One is likely to experience distortions of perceptions. The colour of a leaf may seem exceptionally intense, or extraordinary images and patterns may be seen behind closed eyes, and the sense of time and place may get altered. Cannabis is a plant (also known as hemp) that is also cultivated in many parts of the world. The flowering head of the female plant produces most of the resin that contains the psychoactive constituents. Cannabis is usually smoked, or consumed with food or in a drink. It is a depressant drug with hallucinogenic properties. Marijuana and hashish are also obtained from this plant. Incidentally, marijuana is the most commonly used illegal drug in the world. Ecstacy is a synthetic psychoactive drug, which comes in the form of pills and acts both as a stimulant and psychedelic. It produces an energizing effect as well as distortions in time and perception. LSD is synthesized from alkaloids found in ergot, a fungus that attacks cereal crops. It was first synthesized by the Swiss chemist Albert

Hofmann who discovered the hallucinogenic properties by accident. LSD alters experience of senses, emotions and awareness. How wide spread is drug abuse in India? According to a study conducted by the United Nations Office on Drugs and Crime and the Ministry of Social Justice in 2004, there were 8.75 million users of cannabis, 2.04 million users of opiates such as heroin, and 0.29 million users of sedatives. According to media reports, India has become a transit route for drug traffickers, who smuggle heroin from the opium producing areas of Afghanistan and Myanmar, to other parts of the world. Indeed, the culture has enormously changed in the last couple of decades.

But, why do our youth fall prey to drugs anyway? The reasons could be numerous and may vary from one group to another. According to some psychologists, the rich and the famous have all the materialistic pleasures, and therefore there is certain vacuum in their lives. They need something more to excite them, and the drugs provide the easy answer. For them cocaine is the drug of choice, being costliest in the market. Then there are youngsters who get into drugs to escape from reality. To them drugs provide a false sense of being in control and temporary state of euphoria. Gradually they become habitual drug abusers and develop a craving for it.

However, drug abuse could turn fatal when an abuser overshoots his capacity or when these substances are mixed with medication, alcohol or other drugs. Everybody has a capacity for drug intake, but when they go beyond the tolerance level of their bodies, it could prove fatal. What does the law say in this regard? If one is caught even with one gram of drugs for personal consumption, the punishment varies from imprisonment of six months to one year, or a substantial fine. However, if one is caught with larger possession of drugs, or selling or marketing the same, one may be imprisoned for ten years or more or fined heavily. Certainly we need stricter laws, and stricter enforcement of these laws to counter the invasion of drugs amongst our youth.

We have come a long way since the days of *sura* and *aphena*; and from caffeine to cocaine. What is the solution then? There is no gainsaying the fact that there is plenty of awareness on the dangers of smoking, but very little on drug abuse. Merely terming drug abuse as illegal cannot solve the problem. It would only make the youth more curious to try it out. What is required is a concerted campaign on awareness and the dangers of drug abuse especially amongst the youth. Equally important is the rehabilitation of those who have already fallen victim to it. They need care and they need help. This needs to be a part of our science awareness campaigns.

(August 2006)

Dwarfed – Still a Wanderer*

For over seventy five years Pluto has been among the nine planets thought to make up our Solar System. From our early childhood, we have recognized Pluto as the tiniest and the farthest member of the Sun's immediate family. In 1930, the twenty-two year old American astronomer Clyde Tombaugh discovered Pluto at Lowell Observatory in Arizona. On 24 August 2006, the International Astronomical Union (IAU) at its meeting in Prague stripped Pluto of its planethood, and the number of planets was shrunk to eight. It may be of interest to note that the same body had recognized it as a planet in 1930! Pluto may no longer find a place in textbooks as the ninth planet in our Solar System. It would rather be called a "dwarf planet". What prompted the scientists to strip Pluto of its status as a planet, anyway?

The word "planet" comes from the Greek word for "wanderer", meaning that planets were originally defined as objects that moved in the sky with respect to the background of fixed stars. When discovered, Pluto was classified as a planet. This was because Pluto was the only known object in the Kuiper Belt – an enigmatic zone beyond Neptune teeming with comets and other planetary objects, in the outer reaches of the known Solar System. In fact, we now know that there are a large number of small objects in the Kuiper Belt beyond the orbit of Neptune, roughly the same size as Pluto. In 1978 Pluto was found to have a moon – rather a companion – that was named Charon. Pluto's orbit

* In August 2006, the International Astronomical Union (IAU) declared that Pluto cannot be considered as a planet.

is highly eccentric. At times it is closer to the Sun than Neptune (as it was from January 1979 to February 1999). Observations also have shown that Pluto's orbital inclination is much higher compared to the other planets. Hence, Pluto travels well above and below the ecliptic – the plane of the Solar System in which the Earth and the other seven planets orbit the Sun. Surely, Pluto is quite different from the rest of its big brothers. This is why some astronomers began casting aspersions over Pluto's status as a planet.

Ever since the beginning of the 21st century, the discovery of nearly Pluto-sized objects in our outer Solar System has caused debates over whether Pluto should be considered a planet at all. In 2002, astronomers discovered an object called Quaoar, which like Pluto, lies beyond the orbit of Neptune. Quaoar measures about 1,250 kilometres in diameter, and is larger than any previously known asteroid and roughly the size of Pluto's moon Charon (diameter 1,212 kilometres). In 2004, astronomers found another planet-like object three times farther from the Sun than Pluto. The object, called Sedna, appeared to be about 1,800 kilometres in diameter or about three-fourths the size of Pluto. When Michael Brown of the California Institute of Technology discovered 2003UB313 (earlier he fondly called it Xena) – now officially named Eris, a Kuiper Belt object larger than Pluto, many astronomers openly started debating if Pluto still had any right to continue as a planet. On the other hand many argued – if Pluto can be a planet, why not 2003UB313, Sedna, Charon and Quaoar? And why not Ceres – the first asteroid to be discovered (diameter of 913 kilometres) in 1801? This is how astronomers began feeling a compelling need to evolve criteria that could help them classify an object as a planet.

The IAU members gathered at the 2006 General Assembly toiled to reach a consensus in an effort to define a "planet". First, it was argued that a celestial body can be defined as a planet if it is in orbit around a star while not being itself a star or a satellite. Second, the object must be large enough for its own gravity to pull it into a nearly spherical shape. The shape of objects with mass above 5 x 1020 kg and diameter greater than 800 km would normally be determined by self-gravity, but all borderline cases would have to be established by observation. With these two criteria, there would be 12 planets in our Solar System – Mercury, Venus, Earth, Mars, Ceres, Jupiter, Saturn, Uranus, Neptune, Pluto, Charon and 2003UB313 (Eris). If in future, more Kuiper Belt objects are found satisfying these two criteria (for which the probability is certainly not small!), it would further change the number of planets, and hence an element of uncertainty would prevail as regards the number of planets. Hence one more stringent criterion was added to the definition of the planet, according to which, the body "must have cleared its neighborhood" around its orbit – in addition to the previous two criteria. Incidentally, the phrase "clearing the neighborhood" refers to an orbiting body "sweeping out" its orbital region over time, by gravitationally interacting with smaller bodies nearby. Over many orbital cycles, a large body will tend to cause small bodies either to accrete with it (grow together into one), or to be disturbed to another orbit. As a consequence, it does not then share its orbital region with other bodies of significant size, except for its own satellites, or other bodies governed by its own gravitational influence. Pluto (or its companion Charon) could not meet the third criterion. At times, it comes within the orbit of Neptune. Further, Pluto lies within the Kuiper Belt and hence is surrounded by myriads of Kuiper Belt objects - it has, therefore, *not* cleared its neighborhood. This is similar to the largest asteroid Ceres that lies within the Asteroid Belt (between Mars and Jupiter) and therefore has *not* cleared its neighborhood. It is here that Pluto lost out and we were left with a family of only eight planets!.

Astronomers at IAU defined two more categories of bodies orbiting the Sun – “Dwarf Planets” and “Small Solar System Bodies”. A “dwarf planet” is a celestial body that is in orbit around the Sun, has sufficient mass for its selfgravity so that it assumes a nearly round shape, is not a satellite, but has *not* cleared the neighborhood around its orbit. With this definition, Pluto becomes a dwarf planet and is recognized as the prototype of a new category of trans-Neptunian objects. Eris and Ceres also become dwarf planets. Status of Charon and a few other Kuiper Belt objects still remains undecided. All other objects except satellites orbiting the Sun are referred to collectively as “small solar system bodies” and include all asteroids.

Many people, including several astronomers, did not take kindly to the demotion of Pluto. Many reacted more than sentimentally. Already efforts are afoot for the reinstatement of Pluto as a full planet. It is necessary to appreciate that science cannot be dogmatic and hence, any accepted theory or hypothesis is always open to scrutiny. With new information coming in, along with verification and validation of observations, we may be forced to change the way we perceive nature and change the age-old beliefs. If not, miracles like the sea water turning sweet and idols of gods drinking milk may continue to occur periodically! We cannot afford to get carried away by the age-old or traditional beliefs; rather we need to muster courage to accept the newly found facts. But for this to happen, it is imperative to have an open and an analytical mind. Indeed, this is how science has advanced through the centuries and continues to advance today. The reclassification has not in any way changed the information we have about Pluto. It has, however, changed our perception about Pluto as a planet.

Even though Pluto’s categorization has changed, its fascination remains. The world’s first spacecraft to Pluto, NASA's *New Horizons*, left Earth on 19 January 2006 on a nine-year voyage. It may even be subsequently dispatched to study a few other objects in the Kuiper Belt. Pluto and the Kuiper Belt are known to be heavily endowed with organic molecules and water ice – the raw materials out of which life evolves. *New Horizons* will explore the composition of this material on the surfaces of Pluto, Charon and Kuiper Belt Objects. Pluto may have been dwarfed, but it continues to be a wanderer. On 07 September 2006, Pluto was assigned the asteroid number 134340.

(September 2006)

Asking Mosquitoes to Buzz Off

Every year the retreating monsoon brings a scourge of mosquitoes and leaves a trail of malaria, dengue and chikungunya claiming many lives and infecting thousands. The trail grows wider as every successive year the microorganisms causing the disease mutate into a more virulent form. Although malaria has been around for centuries, dengue and chikungunya are relatively new. Malaria is caused by a protozoan parasite of the genus Plasmodium. This parasite is transmitted from infected persons by the bite of a female Anopheles mosquito after it has developed in the body of this insect. Anopheles mosquito is thus called the vector (carrier) of malaria. While dengue is caused by any of the four closely related viruses (DEN - 1,2,3, and 4), chikungunya is caused by the chikungunya virus. Both, dengue and chikungunya viruses are transmitted from infected persons by the bite of a female Aedes aegypti mosquito. Thus the mosquito Aedes aegypti is a vector of both the diseases – dengue and chikungunya. This year, soon after the monsoon retreated, dengue has infected some 6,423 people across the country and claimed 107 lives, with Delhi alone reporting over 1,731 cases with 31 deaths till the second week of October. Suspected chikungunya cases exceed 1.35 million while those confirmed are about 1,651. Kerala has been the worst hit with dengue and chikungunya both. Nearly 60,000 people are being treated for chikungnya in Kerala alone, while the virus is believed to have claimed about 80 lives.

The first reported epidemics of dengue (also called dengue fever or DF) occurred in 1779-1780 in Asia, Africa and North America. The term dengue comes from the

Swahili word “dinga” meaning sudden cramp-like seizure. It appeared in Cuba in 1827 and the name was popularly (but incorrectly) identified with the Spanish word dengue meaning “fastidiousness”. The dengue viruses and their mosquito vector have had a worldwide distribution in the tropics for over 200 years. Dengue fever was considered a mild, non-fatal disease and there were long intervals (10-40 years) between major epidemics. A pandemic of dengue began in South East Asia after World War II and has spread around the globe since then. In South East Asia, a more severe form of dengue – dengue haemorrhagic fever or DHF – first appeared in Philippines in 1950. The disease has since spread to many countries in South-East Asia, and has now become endemic in several countries of the region, including India. In terms of worldwide distribution, dengue is second only to malaria. Though dengue fever has been known to be in existence in India for a long time, dengue haemorrhagic fever was first reported in an outbreak which occurred in Calcutta in 1963, with major outbreaks of dengue in 1996, 2003 and in 2005. This year we have been facing yet another major outbreak.

A normal dengue fever is characterized by high temperature, body-ache, joint pain, vomit and rashes. People who suffer from dengue fever have no risk of death, but some of them develop dengue haemorrhagic fever or dengue shock syndrome (DSS). In some of these cases death can occur. These conditions are primarily characterized by low platelet count, bleeding from orifices, stomach ache and low blood pressure, but are controllable with adequate and timely medical care. The bleeding occurs due to damage to the blood vessels, which may range from increased permeability of the blood vessels, causing leakage of blood fluid/plasma into various organs to completely broken blood vessels that causes bleeding. The symptoms and signs of dengue haemorrhagic fever and dengue shock syndrome are related to damage caused to the blood vessels and derangement in functioning in components of blood that help it to clot. With platelet count going down, clotting of blood does not take place effectively. The disease is difficult to detect as antibodies produced take up to four days after infection to test positive in serology tests. With proper treatment, however, the patients with dengue haemorrhagic fever and dengue shock syndrome can recover fully. Like most viral diseases there is no specific cure for dengue fever. Antibiotics do not help. Paracetamol is the drug of choice to bring down fever and joint pain. Aspirin and Brufen are best avoided since they can increase the risk of bleeding.

Chikungunya was first officially identified in Tanzania, in 1953. Soon thereafter, epidemics were recorded in Thailand, Cambodia, Vietnam, India, Myanmar, and Sri Lanka. Incidentally, the name chikungunya comes from the word chikungunde in Makonde language of southern Tanzania and Northern Mozambique on the east coast of Africa meaning “that which folds up” and refers to the contorted (or stooped) posture of patients who are afflicted by severe joint pain, which is the most common feature of the disease. Chikungunya mainly occurs in Africa, India and South East Asia. Since 2003, there also have been outbreaks in Philippines and island nations of the Indian Ocean. Some European countries have also reported chikungunya cases. In India, a major epidemic of chikungunya fever was reported during 1963 (West Bengal, Tamilnadu and Andhra Pradesh) and 1973 (Maharashtra). Although it was recorded especially in Maharashtra during 1983 and 2000, chikungunya has struck India this time on a mass scale essentially after several decades.

Chikungunya resembles dengue fever, and is characterized by severe, sometimes persistent joint pain, as well as fever and rash. It is rarely considered to be life threatening, and is primarily found in urban areas. Like dengue, there is no specific treatment for chikungunya. The time between the bite of a mosquito carrying chikungunya virus and the start of symptoms could range from one to twelve days and can be diagnosed by blood test. The laboratory confirmation of chikungunya virus is important especially in areas where dengue also is present.

Since there is no specific treatment for dengue and chikungunya, what is the strategy to be adopted to control the spread of dengue and chikungunya? Even malaria has returned with a vengeance. Approximately 300 million people worldwide are infected by malaria and 1.5 million die every year. Dengue is endemic in more than 100 countries and the World Health Organisation believes that two-fifths of the world's population is at risk from that disease. The only strategy that is practical and somewhat successful in many parts of the world is the vector controlling, that is, control the breeding of mosquitoes.

DDT as anti-mosquito fumigating agent initially had a dramatic effect. But soon the Anopheles mosquito built up stiff resistance, returning with renewed vigour and numbers. What is more, the world had to deal with the DDT build-up and its harmful effects on fauna and the environment and the use of DDT was banned. Dengue mosquitoes breed in stored and exposed water. Favoured places for breeding are barrels, drums, jars, pots, buckets, flower vases, plant saucers, tanks, discarded bottles, tins, tyres, water coolers and so on, where water can collect. So, the best way to prevent the mosquitoes from multiplying is to drain out water from desert coolers/air coolers (when not in use), tanks, barrels, drums, and buckets. Further, it is better to remove all objects where some water is stored (say plant saucers, flower vases, etc.) from the house, and destroy all containers in which water collects – such as empty bottles, plastic bags, tins, and used tyres. Another simple strategy is to remain fully clothed as a protection against mosquito bites.

Vietnam and Australia have adopted a community based biological approach to control breeding of mosquitoes using mesocyclops, which are shrimp-like water creatures. When mesocyclops were introduced in mosquito breeding areas, they devoured 96-100 per cent of the mosquito population. These natural control agents feasted on mosquitoes and their larvae. It is important to point out that this became possible by involving people and teaching them to deal with the problem themselves instead of relying entirely on the government machinery. Biological methods to counter the bio-threats minimize the cost and harmful side effects.

What is more, it is imperative to reinforce the surveillance mechanisms for the breeding of mosquitoes and watch out for any mutation of the viruses. It is equally important to evolve treatment protocols and procedures to be put in place right down to the level of primary health centres. Otherwise, the history would repeat next year as well after the monsoon and the virus may return with a deadlier strain. Practitioners of medicine and the science communicators need to step out to educate the public on sound methods of coping with the diseases. This would be the best way to ask the mosquitoes to buzz off.

(October 2006)

Already Hot and Getting Hotter

The Earth has been either very hot or very cold during most of its history. Of course, this is true as far as the human beings are concerned. Some fifty million years ago, there was no ice on the poles. Eighteen thousand years ago, there was ice nearly three kilometres thick in parts of Europe. As a result of the huge size of the ice sheets, the sea level was 130 metres lower. Studies show that in some parts of the world, swift dramatic changes took place around that time and temperatures rose by nearly 20° C in a short period of ten years causing wild fluctuations. About ten thousand years ago, the climate settled down to the fragrant, mild and soothing state that we have enjoyed since then. Well, it was around this time that human beings began to progress.

What is it that warms our planet, anyway? Radiation from the Sun passes through the atmosphere and is absorbed by the Earth's surface. A part of the heat absorbed by the Earth is then emitted back to the atmosphere. Gases like water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), Nitrous oxide (N_2O), and a few other gases trap that heat which would otherwise be released into space, thereby raising the temperature of the atmosphere; and subsequently that of the Earth's surface. This naturally occurring process in the Earth's atmosphere is called the greenhouse effect that warms our planet and maintains a pleasant average temperature of about 33° C at the Earth's surface.

The stability of the naturally occurring greenhouse effect is now threatened by the human-made greenhouse gases. Increase in the concentration of gases like CO_2 increases the amount of heat trapped by the atmosphere causing global warming and the change in the climatic pattern. During the past 20 years, about three-quarters of human-made CO_2 emissions were from burning fossil fuels. While the natural processes can absorb only some of the net 6.1 billion metric tons of human-made carbon dioxide emissions produced by burning of fossil fuel each year, an estimated 3.2 billion metric tons is added to the atmosphere each year. Further, of all the greenhouse gases, the single most important gas is CO_2 which accounts for about 62% of the increase in the Earth's greenhouse effect. Methane is a natural byproduct of decomposition; however, significant quantities are also produced via agriculture, animal husbandry, and by fossil fuel production.

True, the world's climate has not much changed since the industrial revolution. Over the past 100 years, the average global temperature has gone up by about 0.6° C. What then is this great fuss about global warming and the climate change? Well, this increase is primarily due to the humanmade greenhouse gases. Levels of CO_2 have increased from around 280 parts per million (ppm) to around 380 ppm now. Studies of ice core show that concentrations of CO_2 have not been so high for nearly half a million years. At the current rate of increase, they will have reached 800 ppm by the end of the 21st century! Beyond 550 ppm it would not be liveable! CO_2 being emitted stays in the atmosphere for up to 200 years, and hence getting those concentrations down will take a long time.

Incidentally, 2005 was the warmest year on record since the end of the last major ice age nearly 12,000 years ago. Indeed, this is a sobering thought for an energy-hungry planet and hence deserves serious attention from both policymakers and citizens. A further rise in temperatures by 1°C will equal the maximum level experienced in a million years. In its 2001 Report, the Intergovernmental Panel on Climate Change (IPCC) predicted that global temperatures would rise by 1.4° C - 5.8° C over the next 100 years, including a 2.7° C - 4.3° C increase over India by the 2080s. Anything much higher than that could lead to catastrophic results.

What could be the possible effects of climate change on us? A warmer world would be extremely harsh on biodiversity. Species in natural ecosystems may attempt to migrate with the changing climate, but may differ in their degree of success. Increases in temperature and changes in rainfall may have significant impacts on water resources, either reducing or increasing water availability. Coastal areas may experience additional sea-level rise that may interact with coastal storms to erode beaches, inundate land, and damage structures. Rise in sea levels could threaten coastal mangroves and wetland systems. Droughts, heavy rains, flash floods, tornadoes, cyclones and forest fires, could become more common. Changing rainfall patterns could also severely affect food security. Climate change could threaten human health - water and vector borne diseases. Cholera, typhoid, malaria and dengue could become more wide spread and virulent.

Already we have started experiencing the heat. The profound impact rising temperatures have had on the melting of Arctic ice provides a window into a future we may all experience. Glaciers in the Himalayas are retreating at an average rate of 15 metres per year since1970s. It is estimated that already some 1,700 species of plants, animals, and insects have moved towards the poles at a measurable rate each year in the second half of the 20th century. We are already experiencing a change in the monsoon pattern with floods in Maharashtra, Gujarat and Rajasthan; and draught in the North-East.

There is no gainsaying the fact that the development and economic growth of a country is intimately linked to the extent of industrialization and hence the use of fossil fuels. Imposing restrictions on development will affect the GDP. According to an estimate, a 30 per cent reduction in carbon dioxide emissions will raise the number of poor by 17.5 per cent. It is; however, clear that profligate use of carbon-based energy sources such as fossil fuels to power homes, offices, cars, aircraft, and industries can go on only at the risk of serious harm to humanity's long-term future. Hence the scientists and economists need to devise ways and means to cut emissions incrementally over several years.

How could we reduce our CO_2 emissions? We have the technology and ingenuity to reduce the threat of global warming today – and it does not involve high costs. By investing in renewable energy we can take essential steps toward reducing our dependence on fossil fuels and oil that cause global warming. Using energy more efficiently and moving to renewable energy would significantly reduce our emissions of heat-trapping gases. CO_2 emissions from cars and other vehicles need to be reduced. Many technologies already exist that can do this. It would also help us reduce our dependence on import of oil. Indeed, one example that could be cited is the introduction of a public transport system based on compressed natural gas (methane) to reduce polluting gases, first introduced in 2001 in Delhi. We also may need to consider alternate fuels like ethanol. But, how can we cap the industrial emissions? Indeed, the cost differential between fossil-fuel-generated energy and some alternatives is already small, and is likely to come down. The technological and economic aspects of the problem are not quite as challenging as many imagine. To reduce the CO_2 emissions, a carbon tax or a cap-and-trade system, such as Europe's Emissions-Trading Scheme could be introduced, which limits how much the total amount of CO_2 producers can emit.

The Kyoto Accord that came into force in 2005 - seven years after it was agreed in December 1997 - aims at curbing the air pollution blamed for global warming. The accord requires countries to cut emissions of carbon dioxide and other greenhouse gases. Some 141 countries, accounting for 55% of greenhouse gas emissions, have ratified the treaty, which pledges to cut these emissions by 5.2 % by 2012. But the world's top polluter - the US - that produces 25 % of the world's total CO_2 emissions has not signed up the treaty. The US says the changes would be too costly to introduce and that the agreement is flawed! Large developing countries including India, China and Brazil are not required to meet specific targets at least for now.

World carbon dioxide emissions are expected to increase by 1.9 % annually between 2001 and 2025. It is estimated that much of the increase would occur in the developing world, where emerging economies like China and India fuel economic development with fossil fuels. Developing countries' emissions are expected to surpass emissions of industrialized countries near 2018. Surely, a fast-growing India must avoid wasteful use of energy. A real difference could be made by heavily subsidizing solar and wind power, expanding forests (since they absorb carbon emissions), building efficient power generation facilities, developing alternate and less polluting fuels, and improving public transport. We cannot avoid all the consequences of global warming, but committing ourselves to action today can help ensure our children and grandchildren inherit a healthy world full of opportunity tomorrow. Climate change is no more an esoteric issue. The slow, insidious changes it will bring over the next century must appear on the radar screens of people and the policymakers of our country. And earlier it happens, the better. It is already hot and getting hotter.

(November 2006)

Fake Medicines Sick Business

We produce the entire range of medicines from antimalarials, antibacterials, antiseptics, antiparasitics, and antivirals to vaccines. Further, our pharmaceutical industry meets most of the country's demand for bulk drugs, drug intermediates, pharmaceutical formulations, chemicals, tablets, capsules, orals and injectables. Surely, the saga of the Indian pharmaceutical industry would make any Indian feel proud.

But, there is every reason to be concerned about the availability of safe and genuine medicines in the market. The figures quoted in the media and by different sources about the extent of spurious drugs in the country have varied anywhere from 0.5 per cent to 35 per cent. It is believed that revenue loss to the industry as a result of fake medicines could be well over Rs. 4,000 crores annually. However, no thorough nationwide scientific study is available as of today. Worldwide sales of fake drugs are estimated at US $ 35-44 billion, and unless the trade is curtailed, it could reach US $ 75 billion by 2010!

What are fake medicines (counterfeit or spurious as they are often called) anyway? One of the most widely used definitions is that of the World Health Organization (WHO), according to which a counterfeit drug is one that is deliberately and fraudulently mislabeled with respect to identity, source, or both. Counterfeiting can apply to both branded and generic products and counterfeit products could include products with the correct ingredients or with the wrong ingredients, without active ingredients, with insufficient active ingredient, or with fake packaging. How do the substandard drugs differ from the fakes? Substandard drugs are genuine drug products that do not meet quality specifications set for them. If a drug, upon laboratory testing in accordance with the specifications it claims to comply with, fails to meet the specifications, then it is classified as a substandard drug.

Periodically, the media report about raids on illegal drug manufacturing units; and seizure and confiscation of fake drugs from godowns or large consignments. However, this is only the tip of the iceberg. Spurious or substandard drugs are a flourishing global trade; and are an expanding racket even in India. It is a business more lucrative than dealing in genuine drugs! In rich nations it is the lifestyle medicines like Viagra that are faked. In developing countries, however, the life-saving drugs are faked, killing thousands every year.

In the early 1990s some 500 children died of kidney failure in India, Haiti, Bangladesh and Nigeria after taking fake paracetamol syrup contaminated with a toxic solvent. No wonder, this was hardly noticed by anyone – except probably by their parents and some doctors! Imagine the public outcry it would have caused if a similar number of children had died after being administered fake medicine in a developed country like the USA or UK. Incidentally, this is just one documented case of a trade in illicit pharmaceuticals that claims countless lives each year. The victims are mostly among the world's poorest that unwittingly purchase cheap, fake medicines. These medicines often contain toxic substances or little or no active ingredients, and yet claim to combat preventable ailments like malaria, tuberculosis and typhoid. Obviously, this diminishes confidence in the health care systems.

Reports from Asia, Africa and the Middle East indicate that a patient may be paying top market prices to buy well-known brands of neomycin eye drops and meningococcal vaccine made of tap water; paracetamol syrup made of industrial solvent; ampicillin consisting of turmeric; contraceptive pills made of wheat flour; and antimalarials, antibiotics and snake antivenom containing no active ingredients!

The scale of the problem was brought to light in a review published in The Lancet Infectious Diseases (volume 6, p. 602). In South-East Asia, half of all medicine sold is thought to be fake! Much of it is the fake version of the new antimalarial drugs based on the molecule artemisinin. It is believed that artemisinin-derived drugs will be vital in curbing the spread of malaria. It is shocking to note that in Cambodia, a survey revealed that 71 per cent of the artemisinin-derived drug 'artesunate' was fake. Across South-East Asia, over 50 per cent of the artesunate packs sold were found to be fake! Fears are growing that the fakes will now follow the real drugs and find their way into the African market. It is believed that fake pharmaceuticals kill more people and cause more harm than the trade in illegal narcotics.

Fake medicines containing toxic substances kill patients directly. When they do not contain any effective ingredients, they fail to treat potentially fatal ailments like malaria, pneumonia, meningitis, typhoid or tuberculosis, thereby increasing morbidity and mortality. Besides evading detection by the health inspectors, antiinfective drugs containing inadequate quantities of the active ingredients (that is, containing sub-therapeutic amounts) encourage the development of resistance among both bacteria and parasites undermining the efficacy of the genuine drugs forcing the patients to look for costlier new generation drugs. These patients could put the entire society at risk by spreading drug resistance.

How does this sick business thrive? The main reasons include consumers' ignorance, lack of stiff penalty for indulging in such activity and a lax regulatory system. A survey in Laos revealed that two out of three pharmacists and four out of five consumers did not even know that fake drugs existed! Re-usage of drugs past their expiry date is yet another menace. Packaging is so nearly perfect that distinguishing a spurious drug from a genuine one is almost impossible. The production techniques of counterfeiters also have become extremely sophisticated.

How do we face up to the growing threat of counterfeit drugs? Indeed, a third of world's countries have no drug regulation or enforcements thereby allowing criminals to invade the markets, bribe the officials, and trade fakes across the borders. Some of the measures suggested in The Lancet Infectious Diseases review paper to counter the threat of fake medicines include availability of good quality inexpensive or free anti-infective medicines to beat the counterfeiters at their own game, legal requirement to report any substandard or counterfeit drugs to the respective national drug regulatory authority which in turn would report to WHO, a surveillance system to monitor counterfeit medicines, and severe penalties commensurate with the severity of the crime for those who manufacture counterfeit medicines.

Considering the gravity of the situation, WHO has set up an agency, the International Medical Products Anticounterfeiting Task Force (IMPACT) in order to bring together all parties hoping to tackle the problem, from Interpol and drug companies to regulatory agencies, customs authorities and charitable donors. In India, the Mashelkar Committee, which studied the various aspects of the growing threat from spurious drugs in 2003, has recommended death penalty for spurious drug racketing and the establishment of Central Drug Administration to effectively tackle regulatory affairs, enforcement, and other issues related to counterfeiting.

14 million people die every year of infectious diseases with 90 per cent of these deaths occurring in developing countries. Asia and Africa make up 72 per cent of world's population, but they consume only 10.6 per cent of the world's drug market. If 10-50 per cent of this drug supply is spurious, it may fatally undermine the public health programmes. For example, the optimum malaria treatment policy for a country, or improving the diagnosis of typhoid, or the delivery of tuberculosis treatment could be severely affected since the quality of drugs used in the field is poor. There is little point in determining the most efficacious drugs if the quality of the drug supply is not monitored and maintained, concludes The Lancet Infectious Diseases review paper.

We need to become more proactive by buying medicines only from reputed and well-established chemists. Finally, we need to educate the public about the ills of spurious drugs through various media and modes. Only then can we hope for a healthier India and a healthier world.

(December 2006)

Polio: The Elusive Frontier

Following the launch of the Global Polio Eradication Initiative (GPEI) in 1988, spearheaded by the World Health Organization (WHO), Rotary International, the US Centers for Disease Control and Prevention (CDC); and UNICEF, polio cases have decreased by over 99 per cent. From an estimated more than 3,50,000 cases in 125 endemic countries in 1988, the number has come down to 1,951 reported cases in 2005. The deadline set to make the world polio-free was 2000 and was later extended to 2005. In 2006, only four countries in the world remained endemic for this crippling disease – Pakistan, Afghanistan and Nigeria, and India.

The word "poliomyelitis" comes from the Greek words for the site of the disease - polios, meaning gray, myelos, meaning marrow, and adding the suffix itis, meaning inflammation. In common usage, the term poliomyelitis is abbreviated to polio. Poliomyelitis (that is, polio) mainly affects children under five years of age. Polio is a highly infectious disease caused by a virus that enters the body through the nose and mouth and is carried to the intestines where it multiplies. Then the virus travels along the nerve fibres or is carried by the blood stream to the central nervous system – spinal cord and brain, producing the disease. There the virus enters the nerve cells and alters them, or damages and kills them. Paralysis results when many cells are destroyed. Initial symptoms are fever, fatigue, headache, vomiting, and stiffness in the neck and pain in the limbs. One in 200 infections could lead to irreversible paralysis, usually in the legs. Indeed, 5 to 10 per cent die when their breathing muscles become immobilized. There is no cure for polio; it can only be prevented.

Although polio is incurable, it can be easily prevented through immunization. Polio vaccine, given multiple times, can protect a child for life. Two types of vaccines are used. One type of vaccine is an inactivated (killed) polio vaccine that is injected – Inactivated Polio Vaccine (IPV) – developed by the American virologist Jonas Salk in 1952. The second type utilizes a live attenuated (weakened) poliovirus administered through oral drops – Oral Polio Vaccine (OPV) – developed by the American microbiologist Albert Sabin in 1960. In countries where the wild poliovirus is still in circulation, the OPV is used because administering OPV requires minimal training and equipment; and hence is recommended by WHO for GPEI. Incidentally, the IPV is used primarily in countries where the wild poliovirus has already been eliminated.

In India, 38,090 polio cases were reported in 1981. This figure dropped to 22,570 in 1985. A decade later, the number of polio cases stood at 1,665. The country recorded only 66 cases of polio in 2005 in 35 districts nationwide, but mostly in Uttar Pradesh and Bihar. True, we failed to achieve the revised global deadline of polio eradication by 2005; it appeared that we were heading there. One last push, it seemed, would stamp the poliovirus out of its last reserves in Western Uttar Pradesh and Bihar. Instead, the virus has returned with vengeance infecting 655 children in 2006 – 530 of them in 51 districts of Uttar Pradesh and 60 in 25 districts of Bihar. The disease seems to have exploded in the last few months in these two states where children are still being paralysed by polio despite receiving 15 doses oral polio vaccine (OPV) each, compared with 10 for the rest of India; and three in the West. This vicious resurgence came as a surprise especially when the country's war against polio had reached in the final stages.

Routine OPV drops are given for individual protection of the children against polio soon after birth. This is followed by three doses at 14 weeks, 9 months, and 1½ years (along with DPT); and the booster dose at 4½ years. However, some children do not develop complete immunity in spite of receiving all OPV doses. An effective way to protect all children from polio is by stopping the circulation of wild poliovirus from the environment. This is possible if all children less than 5 years of age receive additional OPV doses simultaneously as done during the national immunization days. This helps interrupt circulation of wild poliovirus, and hence in eradication of polio. Mass campaigns are undertaken in the form of two national immunization days and the pulse polio programme where children below five are administered OPV twice a year at intervals of 4 to 6 weeks.

But, then why did our polio eradication strategy fail in Uttar Pradesh and Bihar? There are three types (strains) of polioviruses – Type 1, Type 2 and Type 3. Though all the three types can produce the disease, Type 1 is the most prevalent and Type 3 much rarer. The last case of Type 2 polio anywhere in the world was in 1999. The trivalent oral polio vaccine (tOPV) contains all the three strains of live weakened virus seeking to create immunity against all the three known polio types. The administration of this vaccine triggers a local infection and prompts immune response in the intestines. Diarrhoea and other competing viruses in the intestine, which are particularly common in Uttar Pradesh and Bihar, prevent this. It is also possible that that the three strains of polio vaccine compete with each other further reducing its efficacy. Since Type1 poliovirus is widespread in Uttar Pradesh and Bihar, the India Expert Advisory Group for Polio Eradication has recommended increased use of the "monovalent" oral polio vaccine that targets only a single strain – Type1. Incidentally, the "monovalent" OPV containing only Type 1 polio (mOPV1) was found to be three times more effective than the tOPV, which is widely used in

India. However, it would be a challenge to ensure that the virus does not return. It may, however, be emphasized that tOPV will continue to be used for most campaigns in endemic areas and for routine childhood immunization, while mOPV1 would be used as an adjunct to existing immunization activities. One can go back and hit Type 3 later.

Live but weakened strains of the virus used in the oral polio vaccines can occasionally revert to virulence and set off chains of infection. Injectable (inactivated) vaccine, on the other hand, does not carry any risk of a return to virulence. Further, studies in India have shown the injectable vaccine to be highly efficacious. Oral vaccine needs to be stored at temperatures between 2-8°C, while injectable vaccine, on the other hand, does not require stringent cold storage and is stable. Hence, there is a strong case for introducing the injectable (inactivated) polio vaccine – even if it is 20 times more expensive than the oral vaccine. Indeed, there even have been suggestions to adopt a dual strategy by introducing injectable polio vaccine in addition to the routine doses of OPV in our immunization programme.

Smallpox was declared eradicated in the 1970s – no case has been reported ever since. It gives us hope to work against polio. Viral infections and diarrhoea spread in conditions of high population density and poor sanitation. Indeed, poverty, illiteracy, high birth rates, low standards of living, and associated problems in parts of western Uttar Pradesh have made wiping out polio more difficult. These issues need to be integral parts of our polio eradication campaigns. Polio would no longer remain an elusive frontier then.

(February/March 2007)

No Wake up Call but a Screaming Siren*

In the third assessment report published in 2001 by the Intergovernmental Panel on Climate Change (IPCC), it was suggested that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities". Six years later, in February 2007, IPCC released the summary of the fourth assessment report of the working group on Physical Science Basis of Climate Change that holds grim portents for humanity. The Report "unequivocally" states that the rise in the average global temperature since 1750s very likely resulted from an observed increase in the concentration of the greenhouse gases such as carbon dioxide and methane released by human activity. Key data and statistical modelling have now provided incontrovertible evidence to support this view. Incidentally, the term very likely implies a confidence level of over 90 percent. In the previous report IPCC could make such assertion with only 66 to 90 per cent certainty! There is now much greater certainty and understanding about the anthropogenic warming, that is, how human beings are contributing to the global warming.

Burning of fossil fuels, some agricultural practices, and the change in the land use pattern have been generating greenhouse gases like carbon dioxide, methane, and nitrous oxide, trapping heat and producing runaway global warming. The amount of carbon dioxide entering the atmosphere today is 1.3 times more than what it was just 20 years ago. As a result, the atmosphere is warming by about

* This editorial is based on assessment report (2007) on climate change by IPCC.

0.13 degree Celsius each decade. The widespread melting of mountain glaciers and the polar ice caps has already contributed to the rising sea levels, but the rise of sea levels has accelerated since 1993. The global average rate of sea level rise was 1.8 mm per year between 1961 and 2003. However, the rate was faster over the decade 1993 to 2003, about 3.1 mm per year. The oceans have warmed to a depth of 3 kilometres.

If the production of the greenhouse gases continues unabated, the global temperatures could rise by up to 6.4 degrees Celsius by the turn of the 21st century, says the report. By then, the average sea levels could increase by 0.59 metres, the report says. Further, this amount of warming may make the Arctic devoid of ice and lead to a 30 per cent drop in rainfall in many sub-tropical regions, including a huge area from the Mediterranean and North Africa through the Middle East to central Asia, and another across southern Africa. Meanwhile higher latitudes will get wetter as the air warms, and hurricanes may become more intense. It may be of interest to note that global warming contains a deadly time lag. This is because the 80 per cent of the extra heat currently being trapped by the greenhouse gases produced by the anthropogenic activity is being drawn into the oceans. As the oceans warm, more of the heat will remain in the air. Even if the emission of the greenhouse gases were sharply reduced, the world would continue to warm by 0.1 degrees Celsius per decade for some time.

What would be the consequences for India due to global warming? India is one of the 27 countries most vulnerable to sea level rise. A sharp rise in sea level could have a considerable impact, as about a quarter of the population lives within 50 kilometres of the coastline. Big cities like Mumbai and Chennai are also located on the coast. Much of the coastal region has fertile agricultural land. Increase in sea level could lead to salt water entering the ground water aquifers on which people depend for drinking water and irrigating their fields. Powerful cyclones could arise more frequently in the Bay of Bengal during the post monsoon period. Droughts and spells of excessive rain like the deluge that struck Mumbai and Gujarat in 2005 and 2006 could become more frequent. The accelerated melting of the Himalayan glaciers that feed rivers like the Ganges and Brahmaputra will have a profound effect on future water availability. The data for 466 glaciers shows that already their surface area has shrunk by 21 per cent since 1962. Many species of plants and animals may not be able to cope with the climate change and hence may become extinct.

The authors of the IPCC report, however, acknowledge that the report has been conservative. It omits some very real risks either because we have not yet pinned down their full scale; or because we do not yet know how likely they are! Anything qualitative rather than quantitative got knocked out! By and large, the information where there was ambiguity or controversy was not included in the report. These include the physical collapse of the Greenland ice sheet, rapid melting in Antarctica, a shut-down of the Gulf Stream (the warm ocean current in the Atlantic and a key feature of the world ocean circulation system), the release of carbon dioxide and methane from the soil, the ocean bed and melting permafrost (subsoil which remains below freezing point of water throughout the year, as in polar regions); and the rainforest soils. Let us hope that when the complete report appears, it would give much greater attention to these aspects.

With the incontrovertible evidence along with alarming consequences for the global warming as presented in the IPCC report, the pressure on the United States of America, which spews out 25 per cent of the world's total carbon dioxide emissions (and yet refuses to sign the Kyoto protocol) – the highest by any country in the world – is bound to increase to reduce its emissions. True, similar pressure would be on China and India as well though they are not signatories to the Kyoto Protocol, both being developing economies. A culture of efficiency could help reduce the billions of tonnes of carbon dioxide being pumped into atmosphere by power plants, industrial manufacturing, and the transport sector. Business-as-usual attitude can only hasten the devastating impact of the climate change. The IPCC report is no wake up call but a screaming siren for us to be galvanized into action to save this planet, for which very likely (90 per cent, that is!) we are to blame.

(April 2007)

Incandescent Bulbs: A Burnt out Case?

Before the invention of the incandescent bulb, or the electric light as it is commonly called, illuminating the world after the Sun went down was a messy, arduous, and hazardous affair. It took a bunch of candles, oil lamps or torches to fully light up a house. Though fairly effective, they tended to leave a residue of soot on anything close to them. Indeed, this situation continued in our country for decades even after Independence. There is no gainsaying the fact that the incandescent bulb has profoundly changed human existence and our lifestyle ever since its invention. It is one of the few technologies still in use more than a century after it was pioneered in the last quarter of the nineteenth century by Thomas Alva Edison in America and Joseph Swan in England.

Over a century after lighting the world, the humble light bulb finally seems to be on way out making way for the newer, more efficient technologies. Only five per cent of the electrical energy fed into the bulb generates light. The rest is simply wasted as heat. Hence it makes sense switching over to energy-efficient technologies that offer scope for reducing the amount of electricity produced by the power stations that burn fossil fuels; and thereby cutting down carbon dioxide released into atmosphere by them. This is why several governments across the world have proposed legislation to ban the iconic invention of Edison and switch over to the newer energy-saving light bulbs in a bid to cut down carbon dioxide emissions that contribute to global warming. First to propose this was the state of California in the United States. On 31 January 2007, it proposed to ban the traditional bulbs by 2012. Soon after, Australia followed the suit. European Union with its 27 member states would phase them out by 2009.

What are the reliable replacements to the traditional incandescent bulb, then? Already available in the market are the compact fluorescent lamps (CFLs) that are coiled up versions of the fluorescent tube lights. Then there are bulbs and lights based on the light emitting diodes (LEDs), used in car headlights and display screens, that give out huge amounts of light for their size, and use a fraction of the energy of conventional bulbs. However, a few technical deficiencies will need to be overcome before LEDs could replace them. Today, a conventional bulb costs about Rs.10, while a CFL costs about Rs. 80. LED assembly is rather expensive – about Rs. 1,000 to 2,500. Hence, until LEDs become cheaper, CFLs could serve as a stopgap energy-saving alternative.

Since lighting accounts for nearly one sixth to one fifth of the electrical energy consumed, it is obvious that savings in terms of energy and money by switching over to CFLs would be considerable. According to an estimate, if all in Delhi start using CFLs, the city could save over 500 megawatts of electricity. Incidentally, the requirement of electricity in Delhi in peak summer is about 3,500-3,800 megawatts.

How does a CFL work? The CFL tube contains a gas (mercury vapour) that produces ultraviolet (UV) light when an electric current passes through it. When the UV light strikes the phosphor coating on the inside of the tube, it generates white light – the same way as in the familiar fluorescent tube light. The primary difference between the two, however, is in size. Compact fluorescent bulbs are made in special shapes (which require special technologies) to fit in standard household light sockets, like table lamps and ceiling fixtures. In addition, CFLs come with their own built-in transformers that can fit ordinary light sockets unlike a familiar fluorescent tube light. True, there are concerns regarding the use of mercury in CFL, which may prove to be injurious and harmful in case CFL breaks.

Consumers hence need to be suitably informed to use CFLs with caution. LEDs are semiconductor devices that emit light when a voltage is applied across them. The most remarkable change in the way we light our homes is expected to come from LEDs when they become cheap and reliable. Let us see why. Despite the fact that CFLs are much more efficient than the incandescent bulb, they still emit only about 30 per cent of the electrical energy fed into them as light. This compares with the 30 per cent efficiency of existing LEDs, which is expected to go up to 70 per cent. Already some LED-based light sources have started appearing for household lighting. The challenge, however, is to develop devices that can create warmer white light. A pioneer of LEDs quotes in a recent article in *New Scientist* (31 March 2007), "It will be CFLs first, but LEDs may eventually bypass them. It's amazing the incandescent bulb has lasted this long!"

The Fourth Assessment Report of the Inter-Governmental Panel on Climate Change (IPCC) released in May 2007 states that between 1970 and 2004, the global greenhouse gas (GHG) emissions have increased by 70 per cent as compared to the times before Industrial Revolution. Carbon dioxide emissions grew during this period by about 80 per cent (28 per cent between 1990 and 2004); and represented 77 per cent of total anthropogenic (that is, man-made) GHG emissions in 2004. If the world continues to burn fossil fuels along current lines, then the dangerous emissions would rise by 90 per cent by 2030. All countries, including India and China, will have to adopt measures to scale back polluting emissions. Every individual and region has a stake in halting global warming. Under the circumstances, switching over to CFL shall have to be one of our first acts to save this planet from heading towards disaster.

CFLs produce light for just 20 per cent of the energy used by the incandescent bulbs. Further, they last for about 10,000 hours compared to the incandescent bulbs that last only for about 1,000 hours. Using a CFL means manufacturing less number of incandescent bulbs. It is interesting to note that in places where coal is used to produce electricity (which is true in most places), each CFL, over its lifetime, will cut carbon dioxide pumped into the atmospheres by the power plants by about 600 kilograms. We shall need to switch over to efficient technologies that are already available and change our lifestyles to arrest global warming in the coming decades. It is imperative that we immediately switched over to more efficient electrical gadgets, better insulation, and active solar design for heating and cooling. This calls for specially designed awareness campaigns and a challenge to be immediately taken up by science communicators. Surely, charity begins at home.

(June 2007)

Wireless Communication: Much More to Come

In 1895, Jagdis Chandra Bose gave a demonstration of wireless communication in Kolkata Town Hall by transmitting radio waves from the lecture hall through intervening walls covering a distance of 25 metres. It tripped a relay, which threw a heavy iron ball, fired off a pistol, and blew a small mine. Later, Guglielmo Marconi was granted patents for his "wireless telegraph" in 1897. The radio signals, however, could travel only a few kilometres then. Further, only one transmitter and one receiver could operate in any one area. Surely, the future of radio waves appeared quite modest. Since 1900, however, the amount of information that can travel over the same portion of radio waves, called the spectrum efficiency, has improved a trillion times as estimated by Martin Cooper, hailed as the father of the mobile phones.

Remember the good old radio some fifty years ago in your living room? It was a wireless device – a big, woodpanelled machine that faintly glowed and occupied a lot of space. The invention of transistor in 1947 and microprocessor in 1958 brought about a revolutionary change in the way radios functioned. Incidentally, microprocessors integrate transistors and other components onto a single chip. Microprocessors helped get rid of bulky vacuum tubes, crystals and copper coils, and put the assembly of a radio almost entirely on silicon – the second most abundant element on Earth after oxygen. The advantage was that it cost less to manufacture, consumed less power, and allowed the radio to perform better. Today's wireless device is the sleek mobile phone perched in your pocket! What made it possible? It became possible due to the cross-breeding of Marconi's radio and the microprocessor. This is popularly called convergence of technologies and today it implies convergence of radio, microprocessor, internet and other communication technologies.

Over the years, we have witnessed how quickly the innovations occur. The processing power of the chips doubles about every two years according to Moore's law, co-founder of Intel, the world's biggest chip company. As the size of transistors gets smaller, there is more room to add more functions. Such chips are faster and do much more. Further, the cost of integrating new functions is relatively low.

Microprocessors brought in a computing revolution. But, this revolution was mainly about information that involved digitizing documents, photographs and records in order that they could be manipulated effectively. On the other hand, the revolution in wireless communication we are experiencing today is about making digital information about *anything* available *anywhere at minimal cost* that would *not* involve wires and cables. In this way, more information about more things could flow to the place where it is required most.

Despite the fact that radio is 110 years old and the microprocessor only about 50, both the technologies are moving ever closer together with wireless capabilities now being put on computer chips. Needless to say, all the benefits of the computing technology, say, innovation, fast development and low cost automatically become available to wireless communication. The new technology enables control to be exercised from a distance and lets different devices interconnect to do something new and interesting!

At present mobile phones have been getting the most attention. About 3 billion are in use as of now, and 1.6 million are being added every day. What is interesting to note is that the mobile connectivity is spilling over into other areas of wireless communication and is used for linking machines, sensors and objects. Wireless communications have effectively linked the people through mobile phones, but, there are far more things that can be wirelessly linked, from doors to windows to machines, trees and farmlands! Indeed, a large number of hitherto unconnected objects are getting wirelessly connected to networks – from televisions and cars to industrial machinery, and even mousetraps!

In years to come, wireless communications between machine to machine – M2M communications as it is called – will increasingly become part of the fabric of everyday life. After all, there are 6 billion people in the world and 50 billion machines! M2M devices use integrated cellular radios to exchange data with other machines over existing cellular networks. It could be a mobile phone and a computer with Bluetooth connectivity. Virtually any piece of machinery, from electricity meter to a burglar alarm, is suitable for M2M communications. Surely, M2M market is much bigger than the mobile phone market! M2M communications is a new business concept, borne out of the original telemetry technology, used for automatic transmission and measurement of data from remote sources by wire, radio or other means.

Using wireless communications, carmakers have begun monitoring vehicles so that they know when to replace parts before they fail, based on the changes in vibration or temperature. In case of a theft or a crash, wireless chips fitted into the car could tell the emergency services where to come and what has happened. Consider light fixtures in a building. If every fixture contained a small wireless device, it would be possible to control lighting more effectively. If every such device were programmed to serve as online smoke detectors, they could signal a fire and even could show its location. They could even act as a security system or provide Internet connectivity to other things in the building. An interesting example is from Britain in which mousetraps are fitted with a small sensor and a wireless module, and placed in buildings. They can notify the building staff when a rodent is caught! In future, forest rangers could drop sensors from aeroplanes to detect fires, showing their exact location and how fast and in which direction they are spreading. Chips even could be placed inside humans as a means of identification, or to measure body functions and transmit information from inside the body.

In the first half of 20th century, electric motors appeared in every device from eggbeaters to elevators. In the second half, computers monopolized all kinds of different machinery from spacecraft to car and coffee machines. In the next fifty years, M2M wireless technology may well become an integral part of objects. It could be frightening at times, but the results could be immensely useful.

(July 2007)

An Orbiting Home

Space Shuttle *Atlantis* finally landed at the Edwards Air Force Base in California on 22 June 2007 bringing Sunita Williams and her six fellow astronauts safely back home. Sunita was launched aboard the Space Shuttle *Discovery* on 10 December 2006 to join the crew of the International Space Station (ISS), orbiting the Earth at an altitude of 350 kilometres. Her journey lasted for 195 days, the longest space flight for any woman. With her four excursions spreading over 29 hours and 17 minutes, she became the most experienced woman space walker. On 16 April 2007, Sunita ran the first marathon by an astronaut in orbit. She finished the Boston Marathon in four hours and twenty four minutes that she ran tied down to a treadmill while orbiting in the ISS. And all this during her very first journey into space! Incidentally, American astronaut Clayton Anderson, launched on *Discovery,* replaced her as the new flight engineer on the ISS.

The space shuttle is the most complex space vehicle built till date. It blasts off like a rocket, flies like an aircraft, and lands like a glider. The shuttle – also called the orbiter – can fly hundreds of times. This is why it is called the Space Transport System (STS). Incidentally, the mission STS-117 that brought Sunita back was the 118th Space Shuttle flight, and the 21st U.S. flight to the ISS. Space shuttle carries large payloads to various orbits, provides crew rotation for the ISS, and performs servicing missions. Some of its notable payloads that the shuttle carried included ISS components, Hubble Space Telescope, Chandra X-ray observatory; and *Galileo* and *Magellan* spacecrafts.

There have been numerous failed space missions involving launch vehicles and satellites, including that of India. Surely, the loss is much too poignant when precious human lives are lost. In the 46-year history of the manned space flight, 21 lives have been lost. Despite the fact that the road to space is too bumpy and hazardous, why do we feel so fascinated by space; and what is it that keeps on luring us into that infinite void again and again? And, how is it we are so keen to establish a space station some 350 kilometres above the Earth? For some, space stations are a place to do cutting edge scientific research not possible on Earth. For some, this is where unique materials like crystals, semiconductors, and pharmaceuticals can be manufactured in better forms than on Earth. Many think of space stations as staging points for expeditions to the planets and stars. USA and Russia have had orbiting space stations since 1971. ISS is the largest international scientific and technological endeavour ever undertaken that draws on the resources and scientific expertise of 16 nations around the world, viz., USA, Russia, Canada, Japan, eleven members of the European Space Agency, and Brazil, and is under construction since 1998. Earlier, the date of completion of the ISS assembly was expected to be 2004, but, the *Columbia* disaster in 2003, in which Kalpana Chawla perished along with her six fellow astronauts, forced the schedule to be revised. Now, the projected date of completion is 2010, with the station remaining in operation until around 2016 with facilities for six crew members to reside, as against three today.

As of today, the ISS is already larger than any previous space station. It is continuously inhabited since 2 November 2000 – a home in orbit for the visiting crew. At present, space shuttle and the Russian *Soyuz* ferry the crew. Experimental equipment, fuel and consumables are and will be delivered by all vehicles visiting the ISS: the space shuttle, the Russian *Progress*, and European and Japanese space vehicles in future.

But why so much fascination with the space station anyway? We are already familiar with the benefits we have reaped through space research in the fields of telecommunications, weather prediction, and radio and television broadcasts. Remote sensing satellites have been helping us in mapping and managing our natural resources. ISS is a permanent laboratory where gravity is only about one thousandth of that on the Earth, and temperature and pressure can be manipulated for a variety of scientific and engineering pursuits in ways that are impossible in groundbased laboratories. In microgravity, purer protein crystals can be grown that can help better understand the nature of proteins, enzyme and viruses leading to development of new drugs and treatment for cancer, diabetes, emphysema (an abnormal condition of lungs) and immune system disorders. Tissue culture (growing living cells) for long periods in such an environment could help develop new treatment of cancer without risking harm to patients. Further, fluids, flames, molten metal and other materials would form a subject of basic research on the space station. They all behave differently in reduced gravity.

Observations of the Earth from orbit can help the study of large-scale, long-term changes in the environment and monitor climate change as a result of global warming. The effects of longterm exposure of reduced gravity on humans like weakening of muscles; changes in the way the heart, arteries and veins work; and the loss of bone density, among others, could be studied aboard the station. These studies may lead to a better understanding of the body's systems and similar ailments on Earth. Further, a thorough understanding of such effects and possible methods of counteracting them is required to prepare for future longterm human exploration of the solar system.

The new focus for the manned space program is to go out beyond Earth's orbit for purposes of human exploration and scientific discovery. And the International Space Station is a stepping-stone on the way. On the space station, it would be possible to learn how to live and work in space, and build hardware that can survive and function for the years required to making the round-trip voyage from Earth to Mars. Incidentally, journey to Moon takes only three days. Indeed, throughout history, the great nations have been those that are at the forefront of the frontiers of time. This was true for India in the ancient times. Britain became great in the 17th century through its exploration and mastery of the seas. In the years to come, the frontier will be space. Today, we need to catch up with the rest of the world, and *Chandrayaan*, India's mission to Moon to be launched in 2008, is only one small step in this direction. It is, however, needless to say that the ultimate goal of space exploration has to be universal peace and progress of humankind.

(August 2007)

Rivers at Risk

Most of the ancient civilizations grew along the banks of the rivers. Even today, 41 per cent of the world's population lives in river basins and depends on rivers for survival. A river may have a source in a glacier, a spring, or a lake; and begin as a small stream and grow wider as smaller streams and rivers join it. Eventually, it flows into a sea or an ocean. It does not have any doubt about where it is going; and it does not want to go anywhere else! There was a time when that was true, but not any longer! A river's strength is sapped by dams and irrigation works diverting water to farmlands and city water supplies. The Rio Grande River on the border of USA and Mexico often fails to reach the Gulf of Mexico. The once mighty rivers like the Indus, the Nile in Egypt, and the Colorado in USA also have to struggle to touch the ocean.

Freshwater ecosystems are rivers, streams, springs, lakes, ponds, groundwater, floodplains and wetlands. Rivers are surface waters flowing down from higher altitude to lower altitude, and it is in the river basins that nature gathers and delivers water for human use. Rivers provide habitat for diverse flora and fauna, sediment and nutrient retention, transport, electricity generation, recreation and tourism. In India and other developing countries, such freshwater ecosystems and biodiversity provide food, income and livelihood to rural communities. However, freshwater environments tend to have the highest proportion of species threatened with extinction; and today the threats to freshwater ecosystems are immense. Incidentally, more than 20 per cent of the world's 10,000 fresh water species have already become extinct, threatened or endangered.

What are the challenges faced by a river during the course of its journey? Water extraction is a major challenge, but not the only challenge. Dams and canals destroy habitats that are home to several plant and animal species. Physical alteration, habitat loss and degradation, over-fishing, pollution and introduction of invasive species threaten the freshwater ecosystems and their biological resources. Incidentally, an invasive species is a plant or an animal that is intentionally or unintentionally introduced to a region in which it did not naturally evolve, and in its new environment, it may grow to overwhelm native species and communities. Further, freshwater ecosystems naturally filter and purify water, but this ability is impaired by excessive pollution and habitat degradation. Hence, pollution can turn life-giving waters into a hazard to health. Finally, global warming and climate change could completely change the very character of the river we have known for thousands of years.

It may now become impossible to preserve rivers as life-giving watercourses unless we address the factors that threaten their health with a sense of urgency. This is the stark message contained in the assessment of the world's 10 magnificent rivers in different continents released by World Wide Fund for Nature (WWF) some time ago. According to WWF assessment, in the last fifty years we have altered the ecosystems more rapidly and extensively than in any other period of history, the major causes being the rapid population growth, economic development and industrialization that have led to the unprecedented transformation of the freshwater ecosystems and the consequent biodiversity loss.

According to WWF Report, the Salween (Asia), the Danube (Europe) and the La Plata (South America) face heavy threats from navigation and damming. The Rio

Grande (USA) and the Ganges face problems from overextraction of water for increasing irrigation and domestic consumption. The Indus and the Nile (Africa) face the threat from climate change. The Indus depends heavily on glacier water, while the Nile basin is very sensitive to increase in temperature because of its high rate of evaporation. The Murray- Darling in Australia is a victim of invasive species. The Mekong (Asia) faces the problem of over-fishing. Finally, the Yangtze (China) is a victim of high pollution. WWF has relied upon eight international studies to make this assessment. However, we must note that most of the rivers suffer from the various factors described here to a lesser or a greater extent.

The warnings of WWF should serve as a reminder that time may be running out for our rivers, let alone the Ganges. The Ganges is a biodiversity rich and culturally important river system. An estimated 60 per cent of flows of its tributaries are used for agriculture. WWF projection indicates that the annual renewable flow of the Ganges could slip into a situation of scarcity by 2025 despite the fact that per capita supply at present is generally adequate. Further, climate change has been affecting the Himalayan glaciers which provide an estimated 30 to 40 per cent of present flows. Environmentally disruptive projects, that is, dams are used to store vast quantities of water for farming, drinking, and power generation. At this juncture, one may note that according to a recent study, hydroelectric plants release millions of tonnes of polluting greenhouse gases - carbon dioxide and methane - into the atmosphere every year as bacteria degrade the vegetation submerged in their giant reservoirs! Hence, hydroelectric power may not be as green as we may think! Next, surface water extraction is increasing in States that lie along the river's course; and more diversion of waters is planned. There is no gainsaying the fact that grave environmental threats such as pollution, building of unsustainable dams, excessive extraction of water, climate change, and over-fishing are taking their toll on the health of our rivers. By and large, what holds true for the Ganges also holds true for other rivers of our country.

What are the immediate measures we need to take? First and foremost, we must make more economical use of water for agriculture and other purposes. Action plans to clean up rivers like the Ganges and the Yamuna must involve community participation. We shall also need to devise an effective system to conclude enforceable water agreements among States that share the same river basin. Rivers and their rich diversity of plants and animals can be better protected if community-based rainwater harvesting practices are strengthened. Since burning of fossil fuels contributes to global warming and thereby accelerating the melting of the Himalayan glaciers, it is imperative to reduce the use of fossil fuels and develop renewable sources of energy. This holds true both for developed as well as the developing nations. Massive investments in sanitation, sewage treatment, and pollution control are equally important to keep the rivers healthy. But, the real challenge would be to transform this effort into a people's movement. Our rivers will then continue to flow nurturing the communities for ever.

(September 2007)

India at 60 - Growth and Challenges

On 15 August 2007, we completed sixty years as a free nation. Looking at the growth and achievements of our country during this period, one cannot but experience a sense of pride and triumph. This is understandable when one considers India's institutional stability and the economic success in the past one and half decades. Democracy, information technology, and a worldclass corporate sector have been the principal elements that have made India a force to reckon with in the world today. For half a century before Independence, the Indian economy registered virtually no growth at all. In the first three decades after Independence we grew at 3.5 per cent per annum. In the next three decades our annual growth rate went up to nearly 6.0 per cent. In the past few years the growth rate has been closer to 9.0 per cent per annum. Surely, this has been a great and exciting adventure that transformed our country from a colonial, agrarian economy into a modern, industrializing, and knowledge-based economy – within the framework of a liberal and secular democracy. How did it happen? It happened through the systematic application of science and technology in diverse spheres of human activity and liberalization of economy.

During the last sixty years, we have produced world-class scientists and technologists, entrepreneurs, economists, doctors, journalists, bureaucrats, and politicians. They have been instrumental in transforming our country into a modern resurgent India. Our life expectancy has gone up from 32 years at Independence to 65 years. In 1951, we had only 0.339 million kilometers of roads, today we have 3.38 million kilometers. Our steel production has gone up by over

50 times and cement production by 20 times. Our exports have gone up from a few million US dollars at the time of Independence to over 125 billion dollars. India's achievements in pharmaceuticals, including in the production of cheap generic substitutes for life-saving medicines, have made a huge difference in bringing down the costs of tackling diseases and epidemics including AIDS.

Let us have a quick look at India's achievements in specific areas. The Green Revolution, initiated by M. S. Swaminathan, transformed the country from a food-deficit economy into a food surplus economy. It was a combined result of the development of better strains of wheat and rice and modern methods and techniques to raise agricultural production. As a result, the famines of the kind of the Great Bengal Famine of 1942-43 have not been allowed to occur till date, although our population has grown from 350 million in 1947 to 1,100 million now. Next was the White Revolution. At Independence, there used to be an acute shortage of milk. Today, we are the largest producers of milk in the world. This became possible due to the extraordinary vision of the milk cooperatives of Verghese Kurien – the Milkman of India! India's programme in nuclear research and nuclear energy production as conceptualized by H. J. Bhabha has made possible the successful utilization of nuclear energy in power generation, defence, medicine, and other applications. The peaceful use of nuclear energy has earned India the reputation of a responsible player in this field.

Starting with the modest Nike- Apache rockets in the nineteen sixties for the study of ionosphere, and the Satellite Instructional Television Experiment (SITE) in mid-nineteen seventies, we have come a long way in the utilization of space science and technology, thanks to the vision and foresight of Vikram Sarabhai. We not only make our own sophisticated satellites for telecommunication, radio/

television broadcasts and weather, and remote-sensing, but also launch vehicles that place our communication satellites into the geosynchronous orbit. It is this technology on which is based our ambitious defence programme of development of a variety of missiles. The telecom revolution initiated under the leadership of Sam Pitroda at C-DoT has brought urban and rural India closer together. Software technology programme spearheaded by N. Vittal in 1991 along with the economic reforms of 1991 laid the foundation for the software revolution in the country. It may be of interest to note that India's Information Technology exports grew from US 150 million dollars in 1991-92 to 31.4 billion in 2006-07.

The success stories described above show that people and Government can work together to achieve what is thought difficult, or even impossible. However, there are many areas which are still crying out for immediate attention. We take pride in our achievements in the field of literacy. But, 350 million people still remain illiterate. 150 million do not have access to clean drinking water. Nearly 750 million, that is, three fourths of our population lack sanitation. Some fifty per cent of our children are still under-nourished. Basic medicines are still not available in seventy five per cent of villages. Electricity and clean cooking fuel are not available to large sections of the population. And, 260 million are still below the poverty line! What is more, our agricultural production has not kept pace with the burgeoning population. The problem is compounded by the global warming and the changing climatic pattern. Over the years, droughts and floods have become more frequent in different parts of the country. We need to understand the monsoons better. We have made progress in a number of health indicators, but we still struggle with diseases and epidemics that have a bearing on poverty and gender bias. Further, we shall need to focus our attention on issues like re-emergence of infectious diseases due to development of virulent and multi-drug resistant pathogens requiring all scientific and technical skills. We also need to minimize the exploitation of natural resources, conserve environment and ensure sustainable development.

There is no gainsaying the fact that we need a large pool of scientists and trained manpower to address and tackle the issues outlined here. *That is the real challenge.* The number of students opting for science after the secondary stage has dropped from 32 per cent in the early 1950s to 19.7 per cent in the recent years. Young students, particularly, the brighter ones are drifting away from science. Data of college enrollment in the science subjects has revealed that, on an average, about 48 per cent of the students drift out of B.Sc. courses to join professional courses. Well, these are the students who obtain 80 to 90 percent marks at Plus- Two level! Even those motivated few opting for science are taught in colleges which are ill-equipped, have inadequate library and laboratory facilities; are overcrowded and poorly staffed. They are also confronted with outdated curricula and disinterested teachers.

How did it happen? National Knowledge Commission in its 'Report to the Nation' observes that in 1950's, we created a chain of institutions with ample resources and moved research out of the universities. But, we forgot that there are synergies between teaching and research that enrich each other. It is the universities that are the natural hub for research. It further goes on to state that it is time to reverse what happened in the past and make universities as the hub of research once again as in the pre-Independence era. Surely, it is not easy, but the reform of existing institutions must be an integral part of our endeavor to transform higher education. The allocation to education has already declined in recent years to about three per cent of GDP against six per cent recommended in the National Education Policy. We need to foster talent and creativity but ensure that this does not create merely a few pockets of excellence.

After all, today's science is tomorrow's technology, as Professor C. N. R. Rao says. Our achievements in the past sixty years have been spectacular in many areas. However, we still have a long way to go. Tomorrow's world is going to be knowledge-based. Fortunately, we are in an advantageous position. 60 per cent of our population is under 35 years of age – and innovative and constructive ideas emanate from the young minds. Hence, we have the potential to be the world leader in tomorrow's society – be it cutting-edge scientific research; or development of technologies like the information technology, nanotechnology, or biotechnology. Finally, we need to metamorphose our country into a nation of scientifically thinking people. Can we transform this dream into reality in the next sixty years?

(October 2007)

An Adventure That Began Fifty Years Ago*

The Space Age began on the evening of 4 October 1957 when *Sputnik*, an 84-kg aluminium sphere of the size of a basket ball launched by the Soviet R-7 ballistic missile, became the first manmade object to orbit the Earth. In mere half a century, humans have orbited the Earth, walked in space, and set foot on the Moon. As of today, the Earth is surrounded with numerous satellites – some 860 of them – operated by more than 40 countries. Many of them are looking towards the Earth, and many have eyes set outwards into the vast expanse of the universe. Our spacecraft have visited every planet in the solar system, and as of now, a probe is heading for Pluto – now relegated to the rank of a dwarf planet. A month later, on 4 November 1957, the Soviets launched the 509-kg *Sputnik-2* with a dog named Laika aboard. Laika survived only a few hours after the launch in the overheated spacecraft. But, the Soviets made a point. If they could send a dog into orbit, they could send a human being as well. The mission provided scientists with the first data on the behaviour of a living organism in the space environment. Four months after *Sputnik*, the U.S. managed to launch its first satellite into orbit, *Explorer-1*, weighing 16 kg.

The ensuing rivalry produced a series of spectacular achievements and heroes. In 1961, Soviet cosmonaut Yuri Gagarin became the first human in space. The next year, the

* The editorial takes us through the development of space technology, its challenges and future prospects - fifty years after the launch of *Sputnik* – the first man made satellite.

former marine combat pilot John Glenn became the first American astronaut to orbit the Earth. In 1963, Valentina Tereshkova, a Soviet textile worker became the first woman in space. Cosmonaut Alexei Leonov took the first space walk in 1965. Astronauts Neil Armstrong and Dave Scott performed the first docking manoeuvre. On 20 July 1969, Neil Armstrong and Buzz Aldrin landed on the Moon. With the last Moon mission in 1972 completed, the excitement in human spaceflight waned.

In last 35 years, nearly all human space travel has taken place within low Earth orbit; that is, the region that lies between 200-2,000 kilometres above the surface of the Earth. USA and Russia have had orbiting space stations since 1971. The International Space Station under construction since 1998, however, is the largest international scientific and technological endeavour ever undertaken. The space shuttle is the most complex space vehicle built till date. Incidentally, the boundary between Earth's atmosphere and space lies at about 100 kilometres above the sea level. In 2003, China launched its first "taikonaut" into space, becoming just the third country to send humans into space.

Ever since the last manned mission to Moon, unmanned robotic missions have continued to push the frontiers of knowledge probing the vast expanse of the universe. In 1975, *Venera*, the Soviet probe, descended on Venus through the clouds of sulphuric acid; and braving pressures equivalent of 90 Earth atmospheres and temperatures of about 500 degrees Celsius, transmitting first images of surface of another planet. NASA's *Viking* landed on Mars in July 1976 and transmitted pictures of its surface. Launched in 1977, *Voyager-1* spacecraft visited Jupiter and Saturn, and was the first probe to provide detailed images of the moons of these planets. At a distance of 103 AU (that is, at 103 times the distance between the Sun and the Earth), it is still operational. The rovers *Spirit* and *Opportunity* have been treading the surface of Mars since 2004.

Indeed, these robotic missions have taught us a lot – about Moon, the atmosphere of Titan (the largest moon of Saturn), the fractured face of Enceladus (also a moon of Saturn with a very bright surface), and so on. Flying through the tail of comet Wild-2 the spacecraft *Stardust* revealed what it is made of. A Japanese probe *Hayabusa* landed on an asteroid Itokawa in November 2005, and samples from it containing material from the birth of the solar system will arrive back on Earth in 2010. In case either of these objects threatens to collide with Earth, information from these missions could give us clues to divert or destroy it. *Cassini* has been currently touring Saturn and its moons. Orbiting observatories, beginning with Hubble Space Telescope, have been providing a steady supply of breath-taking images of the cosmos.

True, the space shuttle has been a technological marvel, but, it has proved to be fragile, dangerous and expensive. When *Columbia* disintegrated in 2003 during re-entry, the very relevance of human spaceflight was questioned. And yet, manned space exploration continues to excite us and fire our imagination. This is one reason why U.S.A. has outlined a new "Vision for Space Exploration" to return American astronauts to Moon by 2020 and eventually send them to Mars. The U.S. is ordering new rockets, building new spaceships and preparing plans for a permanent base on the Moon. NASA has also embarked on an ambitious programme "Constellation" to build a space transportation system that can not only carry humans to the Moon and back, but also resupply the International Space Station and eventually place humans on Mars. We may note that NASA wants to retire space shuttle by 2010. The *Orion* crew exploration vehicle is a key component of the Constellation programme – which contains a pressurized capsule, life support systems, and a propulsion engine. Ever since the programme was established in 2006, NASA and their partner Lockheed Martin have been working on development of the new rocket launchers, crew and service modules, and upper stages and landing systems. Indeed, NASA Administrator Michael Griffin expressed the hope during the recently concluded 58th International Astronautical Congress at Hyderabad that in 2037 humans will set their foot on Mars.

It would be of interest to note that the space-faring nations including Russia, China, Japan and India are also considering human flights to Moon and beyond in due course of time. India is all set to send its unmanned mission *Chandrayaan* to orbit Moon. However, as the experience with the International Space Station has shown, if such efforts are to be sustained, cooperation among space-faring nations would be vital. Surely, it makes sense to pool resources, both technical and financial, in such expensive ventures. What would be our goals for exploring the solar system, anyway? Monitoring Earth's climate, preparing a defence system against possible collisions with asteroids, continuing the search for life search for life and origins of life on Earth, understand the origin of the planets, and beginning development and testing technology for an interstellar probe. We could look for minerals on asteroids, or even look for new sources of energy, say tapping the rich reserves of He3 found on the surface of Moon, and regarded as an ideal fuel being non-polluting and having virtually no by-products.

Exploration or scientific research is a gamble, and it cannot be expected to pay back in the short term. But, in due course, it could pay back handsomely, as history has shown time and again. Communication satellites have helped bring cricket and football world-cup matches, wars, and celebrations from thousands of kilometres away into our living rooms. They have connected the world through a network of telecommunication satellites. Weather satellites warn us about impending cyclones or hurricanes; and global positioning system (GPS) satellites save us from getting lost on unfamiliar streets. Today we have billion-dollar industries based on telecommunication and GPS satellites. All this due to an adventure that began fifty years ago with an 84 kg metal ball shot into space.

Satellites have allowed a country like India to provide communications and remote sensing services to people in the remotest corners relatively cheaply and quickly. It is hard to imagine all this happening without space. We could have a computer, but we would not be able to get on the internet. Space exploration has brought us several benefits. This is why many countries are in the process of developing ambitious programmes on space exploration and benefit through the applications of the space technology. It may not be a quick-fix solution to raise people above the poverty line, or improve their health, but would certainly assure the nation of a prosperous future. What is more, it could give people a vision of future and help attract young people to study science and engineering.

Surely, it is possible to make a better life for everyone on Earth, and at the same time to reach for the planets and the stars, as Carl Sagan once said.

(November 2007)

Living Beyond Our Means - But How Long?*

Through this column, we have discussed from time to time the threats to our planet arising from climate change, degrading environment, the growing rate of extinction of species, declining availability of fresh water, rivers running dry before they can reach sea, loss of fertile land due to degradation, depleting energy sources, incidence of diseases, the challenge of feeding an exponentially growing population, and so on. These are among the many issues and threats that have remained unresolved over the decades putting 'humanity's very survival' at risk. This final warning comes in the latest report *Global Environment Outlook: Environment for Development* (GEO-4) released by United Nations Environment Programme (UNEP) in October 2007.

It was in 1987 that the World Commission on Environment and Development produced its seminal report, *Our Common Future,* which first popularised the idea of sustainable development. GEO-4 is the fourth report in the series that assesses the current state of the global atmosphere, land, water and biodiversity, describes the changes since 1987, and identifies priorities for action.

What makes GEO-4 so very important for us? Traditional reports generally focus on physical aspects, and see economic and social issues as important but *separate*

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* This editorial is based on *Global Environment Outlook report 2007* released by United Nations Environment Programme (UNEP).

concerns. GEO-4, on the other hand, represents an *evolution* in environmental assessment from a purely bio-physical focus to one that includes social and economic aspects, inter-linkages among different components of the environment and development and outlook for the future. It also capitalises on findings from organisations like the Intergovernmental Panel on Climate Change (IPCC) and many others. The objective of the report is not to present a dark and gloomy scenario, but an urgent call for action. To begin with, it salutes the world's progress in tackling some relatively straightforward problems. It acknowledges the fact that environment is now much closer to mainstream politics everywhere.

GEO-4 acknowledges that there is now "visible and unequivocal" evidence of the impacts of climate change, and consensus that human activities have been decisive in this change. Global average temperatures have risen by about 0.7 °C since 1906. By the turn of the century, the temperature is expected to rise further between 1.8°C and 4°C. It is believed that a 2°C increase in the global mean temperature (above the levels as compared to the times before the Industrial Revolution) is a threshold beyond which the threat of major and irreversible damage becomes more plausible. The average temperatures in the Arctic are rising twice as rapidly as in the rest of the world. Acid rain is now much less of a problem in Europe and North America, but a challenging problem in countries like Mexico, India and China. Sea-level rise will continue for the foreseeable future adversely affecting over 60 per cent of the population worldwide that lives within 100 kilometres of the coast.

Climate change is a global priority, GEO-4 asserts. What lacks is the political will and leadership to address this issue. And yet, there is a remarkable lack of urgency, and a woefully inadequate global response! The threat is now so urgent that large cuts in greenhouse gases by midcentury are needed. Not only developed countries, but rapidly industrialising countries also need to reduce anthropogenic (man-made) greenhouse gases. In particular, we must do more to use and develop renewable energy.

A crucial point GEO-4 makes is that we are living *far beyond* our means. The human population is now so large that the amount of resources needed to sustain it exceeds what is available. Humanity's environmental demand is 21.9 hectares per person while the Earth's biological capacity is only 15.7 hectares per person, on an average! This implies that we are living way beyond our means, consuming 40 per cent more than what the Earth can sustain; and that the well-being of billions of people in the developing world is at risk. How long can we afford to do so?

Irrigation already takes about 70 per cent of available water. By 2025, water use is predicted to rise by 50 per cent in developing countries and by 18 per cent in the developed world. Water quality is declining too, polluted by microbial pathogens and excessive nutrients. Globally, contaminated water remains the greatest single cause of human disease and death. Biodiversity changes are the fastest in human history today. It is alarming to note that species are becoming extinct a hundred times faster than the rate shown in the fossil records. Consumption of fish has tripled since 1961 and today catches are estimated at 250 per cent more than what the oceans can sustain. Today, over 30 per cent of amphibians, 23 per cent of mammals and 12 per cent of birds are threatened. The GEO-4 report points out that a sixth major extinction of species is under way. But, this time it is being caused by human behaviour. Our growing demand for food will mean either intensified agriculture (that uses more chemicals, energy and water, and more efficient breeds and crops), or cultivating more land. Sure enough, either way, biodiversity suffers.

Environmental exposure causes almost a quarter of all diseases. About two million people die prematurely every year from indoor and outdoor air pollution. GEO-4 further states that some of the progress achieved in reducing pollution in developed countries has been at the expense of the developing world, where industrial production and its impacts are now being exported.

Indeed, unsustainable land use is causing degradation, a threat as serious as climate change and biodiversity loss. It affects up to a third of the world's people, through pollution, soil erosion, nutrient depletion, water scarcity, salinity, and disruption of biological cycles. The food security of two-thirds of the world's people depends on fertilisers, especially nitrogen. Population growth, over-consumption and the continued shift from cereal to meat consumption mean food demand will increase to 2.5 - 3.5 times the present figure, the report says. By 2030 developing countries will probably need 120 million more hectares to feed themselves.

In last twenty years, the world has changed significantly – economically, socially and politically. Population has increased to 6.7 billion. Trade is almost three times greater. Consumption has been growing faster than population, but unequally. The total annual income of nearly 1 billion people – the population of the richest countries – is almost 15 times that of the 2.3 billion people in the poorest countries. There are fewer resources to share. The amount of land per capita is about a quarter of what it was a century ago, and is expected to fall to about onefifth of the 1900 level by 2050! By 2025, coastal populations alone are expected to reach six billion. Incidentally, it may be of interest to note that the year 2007 is the first in human history when more than half of all people live in cities.

It is important to realise that the environmental crisis, development crisis, and energy crisis are not separate crises. They all point to the same crisis that includes not just climate change, extinction rates and hunger, but other problems resulting through growing human numbers, the rising consumption of the rich and the desperation of the poor.

What message does GEO-4 carry, then? There is no gainsaying the fact that the world has changed considerably over the past 20 years, but we are yet to make headway towards sustainable development. Surely, we live in a better world than at any time in history, but at the same time, unprecedented environmental change has made us more vulnerable than we have ever been. Change is happening faster than we can keep up with. But, there is a silver lining.

Today, we have much better tools and technologies to tackle some of the global challenges. We have better science, a more informed public, and a more proactive private sector. But, we are yet to cross the threshold of sustained action; and need power to reverse the negative trends of environmental decline. Today, we have a better understanding of the challenges we face. Hence, we can undo and reverse some of the damage now unfolding, and adapt if we cannot do so. But we do not have the luxury of time. Delay would only aggravate the problems, increasing their complexity and cost to address the problems of environmental decline. As stated in *Our Common Future*, "After all, environment is where we live; and development is what we all do in attempting to improve our lot within that abode. The two are inseparable." We must spring into action – now! We cannot make our children pay for our misdeeds.

(December 2007)

The Case of the Indian Monsoon

There is magic in the word monsoon. There is romance in it and there is life in it. This is why the monsoon has inspired many of our art and cultural forms. In *Meghadoota*, the great poet Kalidasa used monsoon as a metaphor to convey love after separation with the cloud as the messenger. Again, in *Ritusamhara*, Kalidasa begins with the description of summer in which the dry weather and the extreme heat conditions make the lands extremely parched. Everyone yearns for a few drops of rain to soak the soil. Then come the much-awaited monsoons and the whole country gets drenched in the fresh monsoon rains. Everything looks full of life with black clouds and the rumbling thunder adding to the magic.

Monsoon in India is no ordinary affair, but is the lifeline of the country. Indeed, the Southwest monsoon accounts for about 80 per cent of the country's rainfall in a year. With only about 40 per cent of country's sown area irrigated, the monsoon becomes crucial in determining agricultural output. There is no gainsaying the fact that too much or too little rain can prove disastrous. Monsoon rain generates food and provides labour; and creates cash flow in the market. Bad rain could even result in dipping stock market and falling corporate investment. Further, a great deal of the country's electricity requirement is generated by water power provided by the monsoon rain. A severe drought could reduce gross domestic product (GDP) in a given year by about 2 to 5 per cent. This is why the progress of monsoon – its onset and performance – is followed with such a keen interest in India. The ability to predict accurately the spatial and temporal distribution of rainfall well in advance can help farmers plan agricultural operations. Incidentally, the term *spatial* refers to distribution of monsoon over different areas or regions, while *temporal* refers to distribution over a period of time.

We must emphasize that monsoon is an extremely complex phenomenon governed by several global and regional factors. Despite intensive efforts for over a hundred years we have not been able to understand the monsoon phenomenon completely. We understand monsoon only in bits and pieces. Indeed, it has remained a mystery! This is why we still cannot accurately predict onset and progress of monsoon – spatial or temporal. But, what are the prospects for predicting monsoon rainfall over India, anyway? Why has the accuracy of monsoon forecasts been so low? What are the projected impacts of global warming on the Asian summer monsoon? These are some of the questions we yet need to answer to understand the dynamics of monsoon.

Monsoon forecasting has a long history in India. The India Meteorological Department (IMD) was established by the colonial Government in 1875 with H. F. Blanford as its first head. After the subcontinent had experienced a devastating drought and famine in 1877, the Government asked the recently established IMD to forecast monsoon rainfall. Blanford noticed an inverse relationship between the snow cover in the Himalayas during the preceding winter and monsoon rainfall over India. Tentative monsoon forecasts were issued on this basis in the initial period. In 1904, Sir Gilbert Walker became Director General of observatories in India. He discovered that when atmospheric pressure was low over South American coast, and high over the Indian Ocean region, rainfall was likely to be deficient. When the reverse happened, the monsoon was generally good. He devised a forecasting methodology using a linear regression model using past data. However, even with this model droughts could not be successfully predicted. Indeed, prediction of droughts has remained elusive even today.

In 1969, it was established by J. Bjerkenes that the air pressure changes noted by Sir Gilbert Walker were in fact the atmospheric components associated with the unusual warming and cooling of the surface waters of the Pacific Ocean known as El Niño and La Nina respectively. The oceanic and atmospheric components of the system are now together termed El Niño Southern Oscillation (ENSO). It was shown that ENSO events strongly influenced the Indian monsoon, with poor rains in years when an El Niño occurred and a good monsoon when La Nina occurred. But the relationship between ENSO and the monsoon has appeared to diminish in recent decades. In 1997 the rainfall was slightly above average despite a strong El Niño event while 2002 saw one of the worst droughts in a century despite only a weak El Niño.

The seasonal mean monsoon rainfall is influenced by the slowly varying boundary conditions of sea surface temperature, soil wetness and snow cover. There is also a study describing a phenomenon called Indian Ocean Dipole (IOD). During the positive phase of the dipole, when the eastern Indian Ocean near Indonesia becomes colder than normal and the western part of the ocean near the Somali coast warms up, it is associated with a good monsoon. In recent analyses, however, it has been shown that while the IOD does not correlate as well with the Indian summer monsoon rainfall, the Equatorial Indian Ocean Oscillation (EQUINOO) correlates much better. EQUINOO refers to the pressure and wind pattern changes over similar areas of the Indian Ocean as the dipole. It is suggested that ENSO and EQUINOO could together account for the droughts and years of excess monsoon rain that India has experienced.

Forecasting the weather is a huge undertaking. Dynamical models that simulate how the ocean and atmosphere interact are important for scientific studies and predicting the monsoon. The computer programmes that provide the raw material for modern weather forecasts employ complex arrays of equations take a set of initial conditions – variables such as air pressure, temperature, ocean current speeds, humidity and so on – and use theories such as fluid dynamics and thermodynamics to work out what sort of weather those initial conditions will evolve into after a given time. To make accurate predictions, the information has to be gathered from as many points on above, and below the surface of the Earth as possible. However, a tiny air movement in one part of the globe can turn into a storm thousands of kilometres away! Minuscule errors or omissions in the initial conditions can blow up into hugely erroneous forecasts. Such 'dynamic' models are useful for forecasts two or three days in advance or for indications of how the monsoon might progress over the following week or so, but not for long-range forecasts. This is one reason IMD uses a forecasting methodology using a linear regression models with past data.

The IMD began its operational forecasts in 1988 using a 16-parameter 'power regression model' that used six regional and 10 global land, atmosphere and ocean variables chosen for observed correlations between the Indian summer monsoon rainfall and the data available from the past. It had a successful run for 12 consecutive years as regards prediction of 'normal' monsoon, but, it had problems predicting the quantity of rain. In 2000, IMD replaced four parameters that had declining correlations with the rainfall. After the drought of 2002, when 19 per cent of the rain never fell, IMD was forced to develop a new model that used 8 parameter set for April and 10 parameter set for June for forecast in 2003. It proved successful in 2003, but 2004 forecast was off the mark by a long way. What was forecast as a normal monsoon turned out to be a drought. The new model with a new methodology for the year 2007 used 8 parameters, the interesting aspect being doing away with regional parameters altogether. The year's monsoon was bountiful, but the new model failed to predict the total seasonal rainfall for the country as a whole accurately. We may note that for past four years, IMD forecasts are issued in two stages. The first is given in April based on March values of the parameters of the model, and the second, an updated one is issued in June based on the May-June data taking into account the development of key forcing meteorological conditions such as El Niño / La Nina.

Predicting monsoon may get even more difficult as a result of the climate change. True, no one is sure about what the effects would be, but it is likely that extreme weather events like storms and hurricanes could become more common in many parts of the world. Surely, such events have far-reaching effects on the distant weather systems that would make forecasting even harder. Further, the predictability of the monsoon is limited by the fact that the mean monsoon circulation may be governed by an intrinsically unpredictable component. Our models are getting better and satellite data more comprehensive and accurate. But, even with such phenomenal developments, shall we still continue to be like Alice and the Red Queen who remained under the same tree howsoever fast they ran and for whatever time?

Under the circumstances, it is imperative that we keep fine-tuning the statistical models for monsoon forecasts and not worry much about the real mechanisms that drive the monsoon and predict monsoon accurately most of the times. Finally, an ambitious programme to understand and model monsoon would imply attracting, nurturing and retaining young scientific talent. This may be the biggest challenge in the years ahead. Then, perhaps monsoon may not remain a mystery for ever.

(January 2008)

A Messenger's Messenger*

After travelling more than 3.5 billion kilometres and three and a half years, the *MESSENGER* spacecraft of NASA made its first flyby of Mercury on 14 January 2008, and beamed back a stream of surprises. The name comes from "*ME*rcury *S*urface, *S*pace *EN*vironment, *GE*ochemistry, and *R*anging," highlighting the project's broad range of scientific goals. The planet Mercury itself is named after the mythological messenger of the gods! The images sent by the spacecraft conclusively showed that the planet resembles the Moon much less than many had previously thought, and has many features unique to this innermost world. Incidentally, this was only the second mission to Mercury after 34 years. Earlier, *Mariner-10* spacecraft of NASA flew by the planet three times in 1974 and 1975. Much of what we knew about Mercury before the recent flyby of *MESSENGER* was based on data from these flybys, even though they provided pictures of only about 45 per cent of the planet's surface.

Indeed, of all the planets in our solar system, Mercury is the strangest. It is invisible to the naked eye except at times of greatest elongation, that is, when it is at its maximum angular distance from the Sun. By virtue of its rapid motion, Mercury seems to be playing hide and seek with us. It never goes more than 28 degrees away from the Sun, and is never 2 hours before or behind it. Even on the day of greatest elongation (28 degrees), it is just on the horizon as soon as the night is sufficiently advanced for it to be seen with the naked eye. Slightest mist on

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* *MESSENGER* was a spacecraft sent by NASA to explore the planet Mercury. It made the first flyby of the planet on 14 January 2008.

the horizon and one cannot observe it! These are some of the inherent difficulties in observing Mercury and this is why it has been far less studied than the other planets. Indeed, Copernicus never even managed to see it from his observatory at Frauenburg in Poland!

Mercury is the innermost and the smallest planet in the solar system orbiting the Sun in a highly elliptical orbit once every 88 days. Transits of Mercury are much more frequent than those of Venus – on an average 13 in each century. It has no natural satellites, and no substantial atmosphere. The surface temperatures on Mercury range from about -180°C to 430°C. The regions facing the Sun are the hottest and the bottoms of the craters near its poles are the coldest. Being an inner planet, it also shows phases like Venus.

But, what makes the planet Mercury enigmatic? It has a face like the Moon that is heavily cratered. What is interesting is the fact that it is an exceptionally dense planet, suggesting that it has a huge metallic core – mainly iron, which accounts for more than 40 per cent of the planet's volume. This is a gigantic proportion compared to Earth's core, which fills just 17 per cent of its interior. Its origin is one of the greatest mysteries of Mercury. While most of the major planets go around the Sun more or less in the same plane, Mercury's orbit is tilted at 7 degrees. While Earth's orbit is nearly circular, Mercury prefers an ellipse. What is more, it even has a magnetic field, though only 1 per cent as strong as that of the Earth.

Even Einstein had an affair with Mercury. The planet's peculiar motion could not be explained by Newton's theory of gravitation alone. The puzzle was finally solved when Einstein applied his General Theory of Relativity that became the convincing evidence of the theory. Now astronomers believe that Mercury holds another secret – how the solar system itself was formed. During the flyby of 14 January

2008, *MESSENGER* found many differences between the surface features of the Moon and Mercury. Unlike the Moon, Mercury has huge cliffs with structures snaking hundreds of kilometres across the planet's face. The data beamed back revealed impact craters that appear very different from lunar craters. One particularly curious crater has been dubbed "The Spider"! A formation like this has been observed for the first time on Mercury, and nothing like it has been observed on the Moon. It lies in the middle of a huge impact crater called the Caloris basin and consists of more than 100 narrow, flat-floored troughs radiating from a complex central region. Incidentally, *Mariner-10* had seen only a part of this basin. *MESSENGER* has shown the basin's fullest extent. Caloris is one of the largest impact craters in the solar system and perhaps as large as 1,550 kilometres from rim to rim!

Next, *MESSENGER* found Mercury's magnetic field different from what *Mariner-10* had seen. On 14 January 2008, *MESSENGER* also made the first measurement of Mercury's magnetospheric plasma. During the next two flybys of *MESSENGER* in 2008 and 2009, and when it eventually enters elliptical orbit around Mercury in 2011 to study the planet for a year, we may learn more about the stability and dynamics of Mercury's magnetic field. *MESSENGER* would come as close as 200 kilometres from Mercury's surface during its orbit. During the recent flyby, *MESSENGER*'s instruments detected ultraviolet emissions from sodium, calcium and hydrogen in Mercury's super-low-density atmosphere – called exosphere. It was probably formed from atoms sputtering off Mercury's surface and coming in contact with hot plasma trapped in Mercury's magnetic field. *MESSENGER* also encountered Mercury's sodium-rich exospheric "tail", which extends more than 40,000 kilometres from the planet, and discovered a hydrogen tail of similar dimensions.

Given the fact that there are inherent difficulties in ground observation of the planet Mercury, how is it that there have been so few space missions to Mercury till date as compared to other planets? This is mainly because reaching Mercury from the Earth poses significant technical challenges since it orbits the Sun so much closer than does the Earth. So, when a spacecraft arrives close to Mercury, it is greeted by a hostile environment and must, therefore, be designed to withstand high radiation and temperatures. The energy required to send a spacecraft so close to the Sun is significant, and an orbital mission only increases this requirement. Incidentally, *MESSENGER* is the first spacecraft for which the technologies needed for a Mercury orbital mission were available and combined in an effective manner.

What would *MESSENGER* look for, on planet Mercury, anyway? The mission is designed to shed light on six key issues: Mercury's high density, its geological history, the nature of its magnetic field, the structure of its core, whether it really has ice at its poles, and where its tenuous atmosphere comes from. The probe is carrying imaging devices which will gather much higher resolution images of much more of the planet than *Mariner-10*, and assorted spectrometers to determine abundances of elements in the crust. It is also carrying magnetometers and devices to measure velocities of charged particles. Detailed measurements of tiny changes in the probe's velocity as it orbits would give details of the planet's interior structure. Mercury's high density implies that a metal-rich core occupies at least 60% of the planet's mass, a figure twice as great as for Earth! *MESSENGER* will acquire compositional and mineralogical information and help understand why it is so dense. Only 45% of the surface of Mercury was imaged by *Mariner-10*! *MESSENGER* mapped another 30 per cent during its recent flyby, and will map the remaining surface during the course of its mission. Mercury has a global internal magnetic field, as does Earth, but Mars and Venus do not. By characterizing Mercury's magnetic field, *MESSENGER* will help answer the question of why the inner planets differ in their magnetic histories.

Through a combination of measurements of Mercury's gravity field and observations by the laser altimeter, *MESSENGER* will determine the size of Mercury's core. At Mercury's poles, some crater interiors have permanently shadowed areas that contain highly reflective material at radar wavelengths. Could this material be ice, even though Mercury is the closest planet to the Sun? *MESSENGER* will find out.

Orbiting so close to the Sun, Mercury feels its gravitational pull most keenly, making it the perfect place to test general relativity. *MESSENGER* is not designed to test fundamental physics. However, fortunately it is not the only mission we can look forward to. The European and Japanese space agencies plan to launch a joint mission to Mercury in 2013, and this one does plan to test fundamental physics. Called BepiColombo, it is larger than *MESSENGER* and will consist of two orbiting spacecraft. One will scrutinize the surface of the Mercury while the other will investigate the details of the magnetic field. It is named after Giuseppe (Bepi) Colombo, the scientist who first determined that Mercury rotates three times for every two revolutions around the Sun, and is not synchronously locked with the Sun keeping the same face towards it, as it was earlier thought. He was also involved in the planning of the *Mariner- 10* trajectory to the planet in 1974.

With two flybys yet to come and an intensive year-long orbital mission yet to follow, we are in for more surprises and data that may help us understand the processes that also produced Earth, Venus and Mars – the other terrestrial planets having a rocky body.

(March 2008)

Emerging Infectious Diseases

Infectious diseases account for millions of deaths every year all over the world. Although the great majority of these deaths occur in developing countries, infectious diseases are not confined by international borders. As a result, infectious diseases present a substantial threat to populations in all parts of the world including developed countries. It is important to note that in recent years, the threat posed by infectious diseases has grown significantly. New infectious diseases have emerged that were unknown just a decade ago. Severe Acute Respiratory Syndrome (SARS), Avian Influenza (bird flu), and the West Nile Virus (that causes West Nile encephalitis) are only some of them. It is also important to note that several known infectious diseases that were once considered declined or eradicated, have reappeared with increased frequency and severity. Further, there is always a possibility for an infectious disease to develop into a worldwide outbreak of an epidemic – a pandemic – which could have serious consequences on the health and economy of a nation.

During mid-1970s, development and use of vaccines had made several diseases rare in many parts of the world. Through an intense vaccination campaign spearheaded by the World Health Organization (WHO), smallpox had been eradicated from the world. It was expected that the eradication of other diseases also would follow. A large array of antibiotics was developed which could treat many of the great scourges of history, from leprosy to tuberculosis. The infectious diseases appeared to be on their way out. This optimism, however, has waned over the years. Polio is yet to be contained in India and a few other countries. We are faced with diseases like Acquired Immuno-Deficiency

Syndrome (AIDS) and SARS. New drug-resistant strains of bacteria have appeared. New strains of diseases like tuberculosis have become resistant to almost all existing antibiotics, and have become a much greater health concern than ever before. Same is the story with malaria parasites. In several cases, the disease causing agent – pathogen – had not been described earlier. In others, a pathogen which could be treated earlier somehow has changed. And of late, altogether new threats have emerged.

How did this all happen? Billions of bacteria belonging to hundreds of different species – both identified and unidentified – inhabit the human body, forming an ecological community living in a state of equilibrium. Most of them are benign to the host and some even provide valuable services. The use of some broad-spectrum antibiotics can, however, disturb the balance dramatically, decreasing the numbers of friendly bacteria. In this situation, other kinds of potentially harmful bacteria, normally present only in small numbers, can overgrow, and may even cause a super-infection. Next, resistant bacteria proliferate when a population of both susceptible and resistant bacteria is exposed to an antibiotic within the host. Susceptible bacteria succumb and resistant bacteria proliferate. However, if the full course of antibiotic is not completed, the bacteria that survive the drug mutate and become resistant to that antibiotic. This is why patients are advised to complete the full course of antibiotic treatment. Use of antibiotics in animal feed is an additional cause of antibiotic resistance. Moreover, bacteria from livestock can get into our water systems.

Bacteria and other microbes move readily from person to person and global travel has only contributed to the dissemination of novel pathogens, including drug-resistant strains. It is important to note that crowding also contributes to the spread of novel pathogens. Hospitals and nursing homes are particularly ideal environments for the exchange of microbes including drug-resistant strains. Cancer treatments and other immunosuppressives (drugs that reduce body's normal immune response) such as those used for transplant patients add to the problem. So does human immunodeficiency virus (HIV) that leads to AIDS. Further, surgery or catheterization that breaches the protective barrier of the skin increases the risk of infection. In crowded cities, and especially in countries where adequate sanitation may be lacking, microbes are brought by immigrants from diverse locations. They can spread rapidly, particularly when immunizations and health care are inadequate.

Zoonoses, diseases that can be transmitted to humans from animals, are harder to eradicate. Further, they may be bacterial (anthrax, plague), viral (rabies, cowpox), parasitic (amoebiosis, tapeworm), or fungal (ringworm). Incidentally, rickettsia is a group of microorganisms having characteristics between bacteria and viruses and can cause many diseases (typhus fever, spotted fever) that are transmitted by parasites like fleas, lice, mite and ticks. Recent example of probable zoonosis is SARS, which has been found in the civet cats and Chinese bats. Avian Influenza commonly found in wild birds and poultry has also infected humans. Even Human Immunodeficiency Virus (HIV) is believed to have jumped from the chimpanzees to humans in Africa and then spread in different parts of the world. We may note that global climate change has already altered the species ranges of a number of animals and plants. Further change could increase the range of vectors such as mosquito that transmit diseases like malaria and dengue.

There is no gainsaying the fact that new human infections continue to emerge all over the world, but the risk is higher in some regions than others; and that the identification of emerging diseases and their "hotspots" warrant greater surveillance. It is in this context that a research paper published in a recent issue of the leading scientific journal *Nature* (21 February 2008) by a team of scientists led by Kate E. Jones assumes significance. It provides a systematic, quantitative analysis of recent patterns of disease emergence. The scientists studied and analyzed 335 emerging disease 'events' (that is, outbreaks of human disease associated with new species or variant of an infectious agent of any type of pathogen) between 1940 and 2004. Of the 335 events, 182 events were caused by bacteria or rickettsia, reflecting a large number of drug-resistant microbes that are present all around us, followed by viruses (85), protozoa (36), fungi (21); and helminths or parasitic worms (11).

The scientists found that more new diseases emerged in the 1980s than in any other decade. According to them, this could be due to the HIV/ AIDS pandemic creating a large population that is highly susceptible to concomitant infections that led to a range of other new diseases in people. An interesting finding of the study has been that zoonoses are the current and most important threat in causing new diseases to emerge - accounting for 60 per cent of events. And most of these, including SARS, Ebola virus, and the H5N1 bird influenza originated in wildlife. The authors have provided the first ever definitive proof that emerging infectious diseases like HIV, SARS, West Nile Virus and Ebola are indeed on the rise. Antibiotic drug resistance has been cited as another culprit, leading to diseases such as extremely drug-resistant tuberculosis.

The authors did not stop with determining the causes and origins of emerging infectious diseases. They took it a step further. To help predict and prevent future attacks, sophisticated computer models were used to help design a global map of emerging disease "hotspots". Their results confirm that emerging infectious diseases are significantly associated with socioeconomic, environmental and ecological factors that provide a basis for identifying regions where new emerging infectious diseases are most likely to originate – emerging disease “hotspots”. Such hotspots, particularly in Central America, tropical Africa and South Asia warrant greater surveillance. Areas that present the biggest potential source for new zoonoses are the whole of the East Asia region, the Indian subcontinent, the Niger Delta, and the Great Lakes region in Africa.

It is interesting to note that most reports of emerging disease events came from developed countries. In the United States alone, there have been more than 100 events reported – almost one third of the total. Such infections include several species of hantavirus (carried by rodents and passed on to humans through infected urine, saliva or droppings causing deadly respiratory disease); fungal infections in hospital patients; and a range of bacterial infections acquired from animal reservoirs. This could be due to significant under-reporting of emerging infectious diseases from other regions of the world due to lower levels of surveillance, as the authors suggest.

Finally, the study calls for substantial investment in the capacity to detect, identify and monitor infectious diseases in regions of the world where the need is greatest. At present, richer countries in Europe, North America, Australia and parts of Asia have much greater efforts channelled in this direction. The authors recommend reallocation of surveillance resources to Latin America, tropical Africa and Asia. Surely, the benefits would just not be felt locally. “In an era of increasing globalization, emerging infectious diseases are everybody’s problem”, says Mark Woolhouse, in an accompanying *Nature* News and Views article.

(Apirl 2008)

Smashing Particles to Understand the Universe*

The world's largest particle accelerator, the Large Hadron Collider (LHC) would go into operation at the European Organization for Nuclear Research, better known by its acronym CERN is situated 100 metres underground near Geneva, where it spans the border between Switzerland and France. This is the largest and the most complex particle accelerator in the world installed in a tunnel of 27-km circumference, or a ring of about 4.3- km in radius. The particles are guided by thousands of cylindrical magnets supercooled to -271.3°C, close to absolute zero! When operational, two beams of sub-atomic charged particles, 'hadrons' – protons or heavy ions – would travel in opposite directions around the tunnel at 99.99 per cent of the speed of light, picking up energy in each lap.

Some of the particles moving in opposite directions would crash into each other at four intersection points at an energy never before reached in a particle accelerator. The maximum energy of the protons would be 7 TeV (tera-electronvolt). This implies the corresponding energy of 14 TeV when they collide head-on! Incidentally, 1 TeV of energy is the energy an electron gains when it accelerates through a potential difference of 1 trillion volts. Further, when the two beams collide, they would generate temperatures more than 100,000 times at the heart of the Sun, concentrated

* The world's largest particle accelerator, the Large Hadron Collider (LHC) started its operation on 10 September 2008. However due to technical difficulty, the accelerator was temporarily shut down on 19 September 2008.

within a minuscule space. As a result of the violent collisions, these particles would be transformed into packets of energy, which would in turn condense back into various intriguing types of particles – some of them never even seen before! Huge detectors and equipment spaced along the tunnel will observe the spray from the collisions for analysis by scientists from all over the world. Incidentally, the largest of the setup, ATLAS (A Toroidal LHC Apparatus), has a detector which is seven stories tall; while the heaviest, CMS (Compact Muon Solenoid), is heftier than the Eiffel Tower! How much is the cost of LHC? Over 5 billion US dollars!

How did it all begin? Over a century ago, in late 1800s, physicists believed that the essential business of science was finished, and that no more fundamental discoveries were expected! The future of truths of physics was to be looked for in the sixth place of decimals! There was perfect order in the Universe, as governed by the Newtonian mechanics with atoms as the foundation of matter. And that the atoms were indivisible. But, beginning in 1895, strange things started happening. Discovery of X-rays, radioactivity, and the discovery of electron established that the atom was not indivisible after all. Einstein's Special Theory of Relativity, followed by the General Theory completely revolutionized the way we looked at nature. Now we had a spacetime fabric in which no two events could be said to be simultaneous. Matter bends space and space directs how the matter moves. Energy and mass are interchangeable. Light behaved both like a wave and a particle. In 1911 Ernest Rutherford announced that atoms are mostly empty space, their mass concentrated in a tiny nucleus orbited by electrons.

Today we know that molecules are made of atoms. Atoms are made of particles called protons, neutrons, and electrons. Protons and neutrons are made of even smaller particles called quarks and gluons. Protons and neutrons are called hadrons, and this is how the LHC gets its name. How about quarks? Are they fundamental or made of yet smaller particles? We do not know! True, electrons are believed to be fundamental particles, as of now. Over the years, physicists have worked out a mathematical model that describes the known fundamental particles that make up matter (classified as 'fermions') and the particles that transmit the forces (classified as 'bosons' after Satyendranath Bose who proposed them). It is called the 'Standard Model', and summarizes the present picture of the field of elementary particle physics. It includes the electroweak theory of weak forces (encountered when a nucleus decays through emission of electrons) and the electromagnetic forces (encountered between electrically charged particles); and the quantum chromodynamic theory of strong forces (encountered within the atomic nucleus between protons and neutrons and which binds together quarks inside the protons and the neutrons). Particles that transmit forces between quarks are called gluons, while those responsible for beta decay (electron emission from nuclei) are the W and Z particles. In electromagnetic interaction, the particles transmitting force are the photons, while the ones responsible in gravitational interaction are called gravitons.

However, the Standard Model developed in 1960s and 1970s does not include answers to many basic questions such as how to unify electroweak forces with strong or gravitational forces. It cannot even explain mysteries of the Universe, answers to which have their roots in the world of fundamental particles. At the time of the Big Bang, the Universe had no dimensions at all. How did the Universe, infinitely dense at the time of the Big Bang, evolve into a vast Universe full of stars and planets we live in today? As the early universe expanded, energy should have condensed into equal amounts of matter and antimatter, which would then annihilate each other on contact, reverting to pure energy. Thus, the Universe should really be empty! But, there is more matter than antimatter and therefore we exist! Given the energy and the temperatures at which the LHC works, the experiments planned may help physicists understand why the Universe grew with just enough more matter than antimatter.

How about the dark matter? What is so 'dark' about it? Observations of the motion of distant galaxies indicate that they are subject to more gravitational force than their visible matter could possibly account for, implying existence of some exotic hidden matter in the mix. Where did this dark matter come from? A theory called 'supersymmetry' could possibly explain this. According to it, every fundamental particle had a much more massive counterpart in the early Universe. Indeed, the electron might have had a massive partner that physicists refer to as the 'selectron'. Similarly, the muon might have had the 'smuon', and the quark might have had 'squark'. Many of those supersymmetric partners would be unstable. However, one kind of particles may have been just stable enough to survive till today without interacting with any other particles. Could they be dark matter? By smashing particles like protons at energies and temperatures that existed at the earliest moments of the Universe, the LHC could reveal the particles and forces that were responsible for everything that followed.

Predicted way back in 1960 by the University of Edinburgh physicist Peter Higgs, the Higgs boson is the only particle hypothesized in the Standard Model that has not been found in any experiment till today. Higgs boson is the key to the origin of the particle mass – and hence could perhaps explain how I weigh 70 kg! This is why it is also called the God particle! It is presumed to be massive compared with most subatomic particles – about 100 to 200 times the mass of a proton, and hence unstable. This is why one needs a huge collider like LHC to produce Higgs. LHC could create a small, compact bundle of energy from which a Higgs might spark into existence for a time long enough to be recognized. Finding it would be a big step for particle physics, although its discovery would not write the final ending to the story! Physicists believe that there must be a Higgs field that pervades all space; the Higgs particle would be the carrier of the field and would interact with other particles.

Until now, Fermilab in USA, the home of particle accelerator Tevatron, has been the frontier for particle physics research. It has found a few important particles, but it may not have enough energy to produce Higgs. When the LHC starts smashing particles, Europe will suddenly become the dominant location for particle physics. But, why spend such huge money and brainpower over such accelerators and smashing particles? Computers we use today have become possible due to the development of microprocessors, and without the development of quantum physics, there would be no microprocessors, no computers, no internet, and no World Wide Web! It may be interesting to note that WWW was invented at CERN, by computer scientist Tim Berners-Lee. Remember the 2007 Nobel Prize for giant magnetoresistence discovered by two physicists independently in 1980s? They had no idea what it might lead to. But, their discovery proved to be crucial for making magnetized high data storage devices for computers and other consumer electronic items like iPods!

But, what is it that a big accelerator like the LHC expected to do, anyway? Accelerators are routinely used by physicists to study the smallest known particles – the fundamental building blocks of all things. LHC is expected to revolutionize our understanding, from the very small world deep within atoms to the vastness of the Universe. The experiments at the LHC are expected to answer fundamental questions like the origin of mass or the nature of the socalled dark matter. It could even give rise to new questions! Indeed, the experimental data using the higher energies reached by the LHC can push the frontiers of knowledge further ahead, helping us understand the fundamental laws of nature better, help confirm established theories, look beyond what we already know today; and also throw up new technologies as by-product. Even before LHC has started smashing the particles, the spin-off it has thrown up is the development of a technology - the Grid - that would make possible Internet 10,000 times faster than the present broadband connection; and allow data storage capacity over the Internet.

(May 2008)

Climate Change and Health

Through this column, we have been voicing concern over the continuous warming of this planet and the consequent change in the climatic pattern the world over. After the report of the Inter-Governmental Panel on Climate Change (IPCC) in 2007, there is now little doubt that the Earth *is* warming, due to the emission of greenhouse gases as a result of human activity. It is clear that the current trends in energy use, development, and the population growth would lead to continuing climate change in an even more severe manner. It will affect the health and well-being of all populations, with impacts escalating in foreseeable future. In particular, this change is bound to affect the basic requirements for maintaining health - clean air and water, sufficient food, adequate shelter, and freedom from disease.

But, what are the risks? Who is at risk? And what needs to be done to protect health from the challenges posed by the climate change? It is these concerns that prompted the World Health Organization (WHO) to choose 'Climate Change and Health' as the theme for this year's World Health Day (in 2008). Surely, climate change endangers health in fundamental ways. According to the issue paper *Protecting Health from Climate Change* brought out by WHO, the aim is to turn the attention of the world community and the decision makers to climate change and compelling evidence from the health sector. There is absolutely no doubt that the climate change *is* real. But, the magnitude of its consequences - especially in regard to health - can still be reduced by taking right actions.

To begin with, let us consider what the risks are. The world has warmed by approximately 0.75°C in the last 100 years. However, the rate of increase in the last 25 years has been much higher - over 0.18°C. In particular, the land regions are warming faster than the oceans. Sea levels are rising, glaciers are melting and precipitation (rainfall) patterns are changing. There has been a global reduction in mountain glaciers and snow cover. From 1900 to 2005, precipitation increased significantly in parts of North and South America, Europe and Asia, but declined in the Sahel, the Mediterranean, southern Africa and parts of southern Asia. Area affected by drought has increased globally since 1970s. Next, extreme weather events are changing in frequency and intensity. For example, heat waves have become more frequent over land areas, frequency of heavy precipitation has increased, and since 1975, sea level has risen worldwide. There is also evidence that frequency of intense tropical storms has increased since 1970s. Most of the observed increase in temperature since the mid- 20th century can be attributed to the increase in the concentrations of the greenhouse gases released by the human activities, mainly CO_2, emitted by burning the fossil fuels.

Continued warming could lead to abrupt or irreversible impacts like melting of ice sheets on the polar lands causing several metres of sea level rise inundating low-level areas. It is estimated that human induced climate change will continue at least for the next few decades. If we place emphasis on the sustainable use of energy, the temperatures could rise by about 1.8°C by the turn of this century. If not, the temperatures could rise by 6.0°C with even greater probability of causing abrupt or irreversible impacts. How will the changing climate affect our health, anyway?

Extreme high air temperatures can kill directly. Indeed, over 70,000 excess deaths were recorded in the extreme heat of the summer of 2003 in Europe. Such extreme temperatures would be the norm by the second half of this century. Heat waves directly contribute to deaths from cardiovascular and respiratory diseases, especially among the elderly people. High temperatures raise the levels of ozone at ground level and other air pollutants, and hasten the onset of pollen season. Pollen and other allergens in the air trigger and aggravate asthma and cardiovascular respiratory diseases. Incidentally, urban air pollution currently causes about 800,000 deaths each year.

Higher temperatures are hastening rates of evaporation of surface water thereby reducing the availability of fresh water. Lack of fresh water compromises hygiene and hence increasing incidence of diarrhoeal disease. Diarrhoea remains one of the biggest killers of children and accounts for a total of around 1.8 million deaths every year. On the other hand, too much water, in the form of floods, causes contamination of freshwater supplies. Both flooding and low levels of water lead to water contamination and bring higher level of illness and death from diarrhoea. Changing rainfall patterns, increased rates of evaporation and melting of glaciers, combined with population and economic growth are expected to increase the number of people living in water-stressed water basins from about 1.5 billion in 1990 to 3-6 billion by 2050, a situation that is bound to amplify the hazards to health.

Warmer temperatures, shifting rainfall patterns and increasing humidity affect the transmission of diseases by vectors like mosquitoes. Malaria, a vector borne disease, currently kills 1.1 million people each year in the world. Malaria is not transmitted in the cooler temperatures associated with higher altitudes and latitudes. Further, the number of mosquito vectors depends on the availability of fresh water breeding sites. But, the changing temperatures and patterns of rainfall could alter the geographical distribution of insect vectors that spread infectious diseases.

As the temperatures rise in the higher altitudes or latitudes, vectors like mosquitoes could find a new breeding ground there. Already there are indications that malaria has spread to sites having a warming trend, say, highlands of East Africa; and dengue to tropical cities of developing countries, including India. Some studies suggest that climate change may swell the population at risk of malaria in Africa by 90 million by 2030s; and the global population at risk of dengue by 2 billion by the 2080s.

Rising temperatures, changing patterns of rainfall, and more frequent droughts and floods are projected to decrease crop yields in many developing countries causing shortages of food supplies. In some African countries, yields from rain-fed agriculture could be reduced by up to 50 per cent by 2020! This could result in severe malnutrition and undernutrition, especially among children, in countries where large populations depend rain-fed farming at subsistence level. Already there are causes 3.5 million deaths each year as a result of nutritional deficiencies the world over, increasing at the same time the vulnerability to diseases such as malaria, diarrhoea, and respiratory infections.

Gradual sea level rise coupled with stronger storm surges, would be more frequent and cause more severe coastal flooding, forcing unprotected populations to seek safer grounds increasing environmental and social pressures in their new locations. Extreme events like these can be followed by outbreak of diseases such as cholera. Contamination of water could give rise to diarrhoea, while waterlogging could provide opportunity for breeding of mosquitoes and spread malaria and dengue.

Who are at risk, anyway? Populations in small island developing states and low lying regions are vulnerable from severe tropical storms and sea level rise. Urban populations and tropical megacities, are exposed to health risks arising from heat waves, floods, air pollution and infectious diseases. Mountain populations are at increased risk of water insecurity, floods, landslides, and infectious diseases. Populations living in the coastal areas would be exposed to the risk of salinization of water resources, and loss of agricultural land from sea level rise, thus affecting their livelihood. But, for sure, the burden of climate sensitive diseases would be greatest for the poorest populations. The women and children in developing countries are particularly vulnerable to death and illness following natural disasters. In the 1991 cyclone disaster that killed 140,000 people in Bangladesh, death rates among women were four times higher than those among men. Death rates amongst children under 10 years were six times more than that of adult men! It is an irony that children in poor countries, who have made the least or no contribution to the greenhouse gases that are causing climate change, are among the most vulnerable to the resulting health risks and will be exposed much longer to the health consequences of a degraded natural environment! Indeed, all populations without exception, in developing or developed nations are vulnerable to the health risks caused by the climate change.

With India's ecological and socioeconomic systems already facing tremendous pressures due growing population, rapid urbanization, industrialization, and a 7,500-km long densely populated and low-lying coastline, India is considerably vulnerable to the impact on health due to climate change. Extreme temperatures and heat spells, change in monsoon pattern, receding glaciers, frequent floods, loss of coastal mangroves, expected sea level rise of 25- 40 cm by 2050s, shifting of lower altitude tropical and subtropical forests to higher altitude temperate regions due to rise in temperatures, would all have sizeable adverse effect on health of her citizens. High temperatures can increase the range of vector-borne diseases such as malaria, particularly in regions where minimum temperatures have currently limited pathogen and vector development.

It is clear that climate change can no longer be considered as an environmental or developmental issue alone. It would affect the health and wellbeing of all populations, with its impacts escalating in not too distant a future. Human health needs to be placed at the centre of environment and development decisions. Protection of health from climate change has to be a part of a basic, preventive approach to public health. Some of the measures would include controlling vector-borne diseases, provision of clean water and sanitation; and reduction of dependence on energy sources that pollute the environment and harm health. These measures would not only improve health now, but also reduce the vulnerability to climate change in future.

(June 2008)

Chronic Lifestyles Chronic Diseases

Through development of vaccinations, antibiotics, improved sanitation and medical attention, it has been possible to eliminate the threat of death from most infectious diseases to a great extent, although we are engaged in a never-ending war against the microbes. Only in recent years, however, there has been an increasing concern on chronic diseases, also termed as "non-communicable" diseases (NCDs) or "lifestyle" diseases. These diseases have their roots in our modern lifestyles. As the name suggests, these diseases are not brought by bacteria or viruses, but by unhealthy lifestyles. Sedentary habits or low physical activity, preference for unhealthy junk foods, excessive energy intake, and addiction to tobacco and alcohol are among the major risk factors responsible for the onset of lifestyle diseases.

Incidentally; the term "lifestyle related diseases" is often used to emphasise the contribution of behaviour to the development of chronic diseases, which include obesity, diseases pertaining to heart and blood vessels or cardiovascular diseases, chronic respiratory diseases, stroke, cancer, and diabetes, among others. There are other chronic conditions and diseases that contribute significantly to the burden of disease on individuals, families, societies and countries. Examples include mental disorders, vision and hearing impairment, oral diseases, bone and joint disorders, and genetic disorders. Indeed, the lives of far too many people in the world are being blighted and cut short by chronic diseases. It was thought such diseases were prevalent exclusively in high-income western countries. This is no longer true. According to a report *Preventing Chronic Diseases: A vital investment* brought out by World Health

Organization (WHO) in 2005, four out of five chronic disease deaths occur in low- and middle-income countries. This holds true for India as well. People in these countries tend to develop diseases at younger ages, suffer longer and die sooner than those in high-income countries. Chronic diseases are currently the major cause of death among adults in almost all countries and the toll is projected to increase even further in the years to come. It is an irony that the people in the third world are suffering from the ill effects of "development" superimposed on the problems of underdevelopment.

The chronic diseases have their origins at young age; and given their long duration, there are many opportunities for their prevention. But, sadly, we rarely utilise these opportunities and take corrective measures. In particular, the term "chronic diseases" suggests chronic disease epidemics that take decades to become fully established. Further, chronic diseases are heavily influenced by environmental conditions and are not the result of individual choices alone. Lifestyle chronic diseases by far are the leading cause of mortality in the world, representing 60 per cent of all deaths. In 2005, out of a total of 58 million deaths in the world, an estimated 35 million people died of chronic diseases. Thus, chronic diseases have assumed the dimensions of epidemic. How about India? The number of deaths attributable to chronic diseases was 3.78 million in 1990, or 40.4 per cent of all deaths. This figure is expected to rise to 7.63 million, or 66.7 per cent of all deaths, in 2020.

Let us have a quick look at some of the major lifestyle chronic diseases. Overweight and obesity can lead to cardiovascular disease – mainly heart disease and stroke. It can also lead to diabetes which has rapidly become a global epidemic, and some cancers. Sitting in the offices or in front of television for long hours and no physical exercises, coupled with high energy food, can lead to overweight and obesity. In India, nearly 20 per cent of the people are overweight! Cardiovascular diseases are the world's number one cause of death, killing 17 million people every year. The causes of cardiovascular diseases are well established and well known. The most important causes of heart disease and stroke are unhealthy diet, physical inactivity and tobacco use. The effects of unhealthy diet and physical inactivity may show up in individuals as raised blood pressure, raised blood glucose, raised blood lipids (essential structural components of living cells along with proteins and carbohydrates), and overweight and obesity.

There are over 100 types of cancers, 40 per cent of which can be prevented by a healthy diet, physical activity and not using tobacco in any form. Tobacco use is the single largest preventable cause of cancer in the world. Tobacco use causes cancer of the lung, throat, mouth, pancreas, bladder, stomach, liver, kidney, and cancer of other types. Environmental tobacco smoke (passive smoking) can also cause lung cancer. It is essential that our youth do not get addicted to tobacco products. That is why the theme chosen by WHO for No Tobacco Day in 2008 was "Tobacco-Free Youth". How about diabetes? While Type 1 diabetes is characterised by a lack of insulin production, Type 2 diabetes results from the body's ineffective use of insulin. Type 2 diabetes comprises 90% of people with diabetes around the world, and is largely the result of excess body weight and physical inactivity. Incidentally, India has the highest number of people with diabetes in the world – an estimated 19.3 million in 1995, projected to rise to 57.2 million by 2025.

Let us realise that chronic diseases do not affect only the high-income countries, and that chronic diseases need to be treated on equal footing with infectious diseases. Chronic diseases do not affect only the rich people. In lowincome countries, the middle-aged adults are equally vulnerable to chronic diseases. Further, chronic diseases, including heart diseases, affect men and women almost equally. Since children or poor people have little choice in choosing their environment or healthy food, we all and the Government have a crucial role to play in improving the health and well-being of the people, and in providing special protection to vulnerable groups. Since the major causes of chronic diseases are known, at least 80 per cent of all heart disease, stroke and Type 2 diabetes and over 40% of cancer could be prevented.

In general, deaths from chronic diseases are projected to increase between 2005 and 2015. The projected increase in the burden of chronic diseases worldwide is largely driven by ageing population and the large numbers of people who are now exposed to chronic disease risk factors. There will be a total of 64 million deaths in 2015, of which only 17 million people will die from infectious diseases, 41 million from chronic diseases; and the rest due to other factors. In particular, cardiovascular diseases will remain the single leading cause of death, with an estimated 20 million people dying, mainly from heart disease and stroke. By 2015, deaths from chronic diseases are expected to increase from 35 million to 41 million.

A recent report, *Preventing Noncommunicable Diseases in the Workplace through Diet and Physical Activity* brought out jointly by WHO and the World Economic Forum says India will incur an accumulated loss of $236.6 billion by 2015 on account of unhealthy lifestyles and faulty diet! There is no gainsaying the fact that the resultant chronic diseases will severely affect people's earnings. What would be the extent of income loss to our country? The income loss to Indians because of these diseases, which was $8.7 billion in 2005, is projected to rise to $54 billion in 2015. China, however, will be much worse off. While its accumulated loss will stand at $557.7 billion, the loss of income of the Chinese will stand at $131.8 billion, almost eight times what it was in 2005.

The report emphasises promotion and implementation of workplace health programmes globally. It says it is possible to influence the health behaviour of a large chunk of the population through improvement of workplace environments. Workplaces should make possible healthy food choices and support physical activity, it says. The study cites scientific evidence that healthy diet and adequate physical activity – at least 30 minutes of moderate activity at least five days a week helps prevent non-communicable diseases. India has already initiated a National Programme for Prevention and Control of Diabetes, cardiovascular diseases, and stroke through a pilot project launched in seven states. Ten per cent of adults in India suffer from hypertension while the country is home to 25-30 million diabetics. Three out of every 1,000 people suffer a stroke. The number of deaths due to heart attack is projected to increase from 1.2 million to 2 million in 2010! In view of the fact that lifestyles are equally important for infectious diseases, the health services need to integrate the response to chronic diseases along with the response to acute, infectious diseases.

What could we do to control the epidemics due to chronic diseases? Let us give up smoking and help our youth doing so. Let us avoid consuming high-calorie fast food and refrain from being a couch potato. And yes, regular health checkups – they are a must. Otherwise, it will only cut short our lifespan and cost the country dear. True, everyone has to die one day, and death is inevitable. But, a life of protracted ill-health is not. Chronic disease prevention and control could help us live longer and healthier lives.

(July 2008)

Feeding the Hungry

The Green Revolution heralded breakthroughs in food grain production, with bumper yields of wheat and rice in particular. Along with improved varieties of wheat and rice, the Green Revolution emphasized the application of agricultural science and the need for modern techniques for greater yields, especially in the third world countries. It began in Mexico in the late 1950s, and spread to Asia including India during the 1960s and 1970s. It continued in China in the 1980s and 1990s. Over a 40-year period, the proportion of hungry people in the world declined from about 60 per cent in 1960 to 17 per cent in 2000. During this period, our granaries became full and India became a net exporter of rice. Indeed, the Green Revolution was a technical and scientific breakthrough and one of the most important accomplishments of the 20th century. Had this not occurred, there would be an additional one billion hungry people in the world today.

It appeared that most countries in the world would be capable of adequately feeding their people as a result of the Green Revolution. The rich countries were even trying to figure out what to do with their huge surpluses of food. Today, however, things have completely changed. Growing population, droughts, changing life-styles and consumption patterns, high oil prices, rush to grow biofuels, and other factors have caused shortages of most of the major food crops. There is a concern over increasing food prices almost everywhere in the world. The cost of producing and transporting food has gone up considerably with the increase in the price of oil. Further, the price of oil does not show any signs of coming down, at least for the time being. The demand for meat, especially in the developing countries, has been steadily increasing. Meat, incidentally takes a lot of grain to produce. Growth in population has made food scarcer and more expensive because demand is outstripping supply. And finally, the climate change, which is here to stay.

What went wrong the world over, then? The Green Revolution promoted exploitation of natural resources that involves heavy inputs in terms of chemical fertilisers, pesticides and irrigation. What is the trade-off for chemical-dependent yield increases? There has been both qualitative and quantitative degradation of land, water, and bio-resources. Fertile lands have become uncultivable due to water-logging and salinisation. Yields have come down because of wrong cropping pattern and faulty usage of fertilisers. Excessive pumping of water has caused such acute depletion of water table that even drinking water has become scarce in many areas.

Often, it is argued that we have already hit the limit of what a given piece of land can produce, and hence it would not be possible to meet the demands of the growing population. However, there is little evidence in favour of this argument. The agricultural scientists have been warning for years that of late the rich governments, that fund most of the world's agricultural research and development, have not been investing enough; and that we are now suffering from the consequences. The governments would be able to mitigate the crisis if they invest in the science that can increase the yields and the infrastructure to get the resulting technologies to the farmers. It takes 15-20 years for the scientific research to filter down to farms. Hence, we must act fast. With focus on right priorities, it would be possible to feed a lot more people, argues Debora MacKenzie in an article published in a recent issue of *New Scientist* (14 June 2008).

After the Second World War, fear of famine and its political impact led rich countries to fund research and development in Green Revolution for the rest of the world, while continuing to boost their yields. Between 1960 and 1980, the food production had doubled and prices fallen. The famine had disappeared in most parts of the world, and the rich countries had huge surpluses of food grain. It was then that the rich countries became complacent and investment in agricultural R&D was slashed. It is interesting to note that investment in agricultural R&D grew at 2 per cent per year during the 1980s, but declined by 0.6 per cent since 1990 every year! Next, research in agricultural sciences was increasingly privatised, and the companies focussed more on their profits rather than increase in the yields! These changes resulted in the slowing down of the rate of food production – although the quantity of grain produced on each hectare of farmland is still rising. We have now reached a point when the production has been outpaced by the increase in demand!

Indeed, for the past eight years, global demand for grain has been increasing faster than supply! While grain yields are increasing at 1.1 per cent per year, the world's population is growing at 1.2 per cent per year! Consider India. In 1980s the average total food-grain production was 146.5 million tonnes, and a population of 684 million. The year 2007-2008 witnessed an all-time high production of 227.3 million tonnes. However, by then the population had jumped to 1,130 million! Although the production had increased by a factor of 1.55, the population had increased by a factor of 1.65, implying a deficit of about 15 million tonnes! Also, changing lifestyles and increasing urbanisation are increasing the demand for animal-based food. This puts further pressure on grain production. We may note that it takes 2 kg of grain to be fed to a cow to make 1 kg of milk. It takes 6 kg of grain to make 1 kg of beef, 2 kg to make 1 kg of chicken, and 1.5 kg to make 1 kg of pork!

Next, diverting food grain to biofuel production also has been playing a part in pushing up the price of food grain. Government subsidies to farmers to grow biofuels in some rich countries have been responsible for 30 per cent of current increases in the price of grain. In addition, Australia, a major wheat exporter, has faced six years of drought. The skyrocketing oil prices have made it expensive to run tractors, transport food and make nitrogenbased fertilizers. Looming shortages have compelled countries like India and China to restrict export of grain in order that their own people are fed. But, this has hit countries like Bangladesh and many African countries which are net importers of food.

True, the situation is alarming, but not hopeless. What could we immediately do under the prevailing circumstances? It is imperative that yields have to be increased by making available existing high yielding varieties to farmers and giving them access to the fertilisers, water and pesticides they need. There do exist technologies off the shelf which can triple the yields in parts of Africa, says a noted agronomist. Then, there is huge potential for what is called 'conservation agriculture'. This implies getting more from the land while preserving soil quality and keeping costs and pollution to a minimum. Research in Mexico has shown that ploughing fields only every few years improves the nutrient content and structure of the soil to such an extent that yields can increase by up to 30 per cent. There is also huge potential for developing strains of rice that are resistant to common pests, or wheat varieties that can thrive in semi-drought conditions. Then, nitrogen fixing trees can be grown amid rows of maize to improve degraded soil and provide nutrients, thereby reducing the need for chemical fertilisers. Even techniques like soil depressions that accumulate moisture could make a difference in drought-prone areas. Experiments that decrease losses due to evaporation from leaves and soil have led to bumper harvests in some parts of Africa.

Genetically modified crops may not always be the solution except in certain circumstances. They are no magic bullet, nor panacea! True, some existing varieties could be cultivated with dramatic effect in many parts. But, what is required is to give an opportunity to the farmers to use these varieties and the access to information to improve the way they farm. Also needed is the basic infrastructure like providing simple methods to store the surplus produce and roads to help farmers take their produce to the market.

Agricultural research does not imply developing new high-yielding grain varieties, or plants resistant to diseases and pests alone. It also implies making best use of knowledge and technologies we already have. Since it takes 15-20 years for research to translate into success on the farms, it is imperative that governments and other bodies start investing in research right away as a long-term measure. We have already achieved Green Revolution once. It helped grain production keep pace with population. We certainly can do it again. But, it would prove quite tougher this time. Energy and fertiliser are more expensive. Water and soil resources have been degraded. And above all, we now have to deal with climate change that has been changing the familiar weather patterns with droughts and deluges that are unpredictable! These are the conditions in which we shall need to work and increase yields to feed the hungry of the world. With a proper research programme we can still do it! We shall be able to do it more effectively if we evolve and scrupulously follow an appropriate population control policy at the same time.

(August 2008)

A Case for Nuclear Energy

India occupies 2 per cent of the world's land mass and currently generates about 2 per cent of the global electricity; and yet has a share of 16 per cent of the world's population. Our annual per capita consumption of electrical energy is only about 480 kWh. For China it is 1,800 kWh, while for USA it is 13,680 kWh! Incidentally, 1 kilowatt hour (kWh) is also called 1 'unit' of electrical energy on which are based our monthly electricity consumption bills. India's total installed capacity as of today is 145,000 megawatts of electricity. However, to achieve even a modestly high level of economic growth, the domestic generation capacity will need to be increased at least *tenfold* in coming few decades, say, by 2051.

At present, thermal sources (coal, gas and oil) provide nearly 65 per cent of electricity, while hydroelectric sources provide 25 per cent of our energy requirements. About 7 per cent of our electrical energy comes from renewable energy sources, while nuclear sources provide for only about 3 per cent of our requirements. Although, the contribution of nuclear energy to power sector today is quite modest, it is destined to play a crucial role in meeting India's energy requirement in coming decades.

Increased availability of electricity is necessary for the progress of any developing country like India. However, mere availability alone is not a sufficient criterion. It also must provide for a longterm energy security, should be sustainable and based on diverse fuel sources and technologies. We must, therefore, examine all fuel resources in the country and tap them keeping short, medium and long term scenarios in perspective. Surely, hydro and renewable sources and technologies must be exploited to the maximum. These, together with coal would meet our short and medium-term requirements.

But, even with full utilization of all existing commercially exploitable domestic hydrocarbon, hydroelectric and nonconventional resources, an increased level of generation capacity cannot be sustained for more than a few decades. How do we meet our long-term energy requirements, then? It is the nuclear resources we shall need to tap. True, our uranium resources are modest, but thorium resources are vast. This is a situation unique to India. Hence, our energy programme has to be on different lines as compared to other countries, where uranium resources are relatively large or readily accessible from different parts of the world. For sure, India's three-stage nuclear power programme takes cognizance of the nuclear resource profile of our country.

Nuclear energy is released when nuclei of heavy atoms like uranium absorb a neutron and break up into smaller fragments. This process is known as fission. During the process, some mass disappears and turns into energy given by Einstein's famous formula $E= mc_2$, where E is the energy produced, m is the mass that is converted into energy and c is the velocity of light. If all atoms of 1 kg of uranium undergo fission, they would produce energy equivalent to that produced by burning 3,000 tonnes of coal! When one uranium nucleus is split, two or three neutrons are liberated, which in turn split more uranium nuclei and liberate more neutrons, and so on. This is what is called a "chain reaction". In nuclear bombs like the ones that destroyed Hiroshima and Nagasaki, this chain reaction goes uncontrolled, resulting in a huge explosion. In a nuclear reactor used for power generation the chain reaction is controlled by absorbing most of the released neutrons, and allowing only some neutrons to cause fission. The energy generated in a fission reaction in the form of heat can be used to raise steam and run turbine to generate electricity.

But, here lies the catch! Not all atoms of uranium can be split by neutrons! In nature, we find uranium atoms of two types - lighter uranium "isotope" with 92 protons and 143 neutrons (denoted by symbol U-235) and heavier uranium isotope with 92 protons and 146 neutrons (denoted by symbol U-238). Only the U-235, present to the extent of about 0.7 per cent by weight in ordinary uranium, is fissile (that is, it can undergo fission), and hence, for use in a nuclear reactor, uranium needs to be "enriched" so that it contains a higher percentage of U-235 isotope to sustain chain reaction. Enrichment, however, is a complex and an expensive process. In such reactors, however, we need to use boiling water or graphite as "moderators" to slow down the speeds of the neutrons so that they can hit the U-235 isotopes and split them. When "ordinary" water (H_2O) is used as moderator, the reactor is called Light Water Reactor (LWR).

To get around the complex and expensive process of uranium enrichment, Canada developed CANDU reactors that use natural uranium (containing both U-235 and U-238 isotopes), but use pressurized "heavy water" as moderator. Incidentally 'heavy' water has hydrogen atom with one proton and one neutron in the nucleus of hydrogen atom (denoted by D_2O), while 'ordinary' water has hydrogen with only a proton as its nucleus (denoted by H_2O). There is one distinct advantage in using Pressurized Heavy Water Reactors (PHWRs). Energy is, of course, produced by the fission of U-235 nuclei, but some of the U-238 nuclei are converted to plutonium nuclei with 90 protons and 149 neutrons (denoted by Pu-239), *which is fissile*. Hence, the "spent" fuel from PHWR can be reprocessed and Pu239 separated which can be utilized as fuel in the second stage reactor. As of today, India has 17 nuclear reactors in operation producing 3,779 megawatts of electricity, two of which are LWR type using enriched uranium while the rest are PHWRs based on CANDU design using natural uranium as fuel. Surely, a few of U-238 nuclei do get converted to Pu-239 in LWRs as well that use enriched uranium as fuel.

India has only about 61,000 tonnes of uranium. But thorium (90 protons and 142 neutrons denoted by Th-232) resources are vast - some 2,25,000 tonnes. Although Th-232 by itself is not fissile, it can be converted to a uranium isotope U-233 by bombarding with neutrons in a nuclear reactor, Now, U-233 is *fissile,* and can be used as fuel in another reactor that predominantly uses this isotope of uranium. Surely, the long-term goal of India's nuclear program is to develop an advanced heavy-water thorium cycle. India's 3-stage nuclear programme employs in its first stage the PHWRs fuelled by natural uranium, and light water reactors, to produce plutonium alongwith power. Stage 2 uses fast neutron reactors, also called Fast Breeder Reactors (FBRs), burning the plutonium to "breed" U-233 from thorium. The blanket around the core will have uranium as well as thorium, so that further high-fissile plutonium is produced as well as the U-233. Then in stage 3, Advanced Heavy Water Reactors (AHWRs) would burn the U-233.

India's civil nuclear programme has progressed at a relatively slow pace as it is not a signatory to the Non-Proliferation Treaty (NPT). Incidentally, NPT is a treaty to limit spread of nuclear weapons. There are currently 189 countries party to the treaty, five of which have nuclear weapons. India did not sign the treaty as it considered it was biased towards the five nuclear weapon states (USA, UK, France, Russia, and China). As a result, India did not have access to nuclear resources or technology available elsewhere in the world. But, this has proved to be a blessing in disguise. Today, India is considered world leader as regards thorium technology which is still under development. The nuclear weapons capability of India has arisen independently of its civil nuclear fuel cycle and uses indigenous uranium. Because of its relative isolation in international trade and lack of indigenous uranium, India has uniquely been developing a nuclear fuel cycle to exploit its reserves of thorium.

India's nuclear industry is largely without International Atomic Energy Agency (IAEA) safeguards, though four nuclear power plants are under facilityspecific arrangements related to India's safeguards agreement with IAEA. The lack of full-scope IAEA safeguards has resulted in India being isolated from world trade by the Nuclear Suppliers' Group (NSG) comprising of 45 nuclear supplier States. It is worth mentioning that India has been scrupulous in ensuring that its weapons material and technology are guarded against commercial or illicit export to other countries.

But, things are looking up. As of now, International Atomic Energy Agency (IAEA) has already cleared the Indiaspecific nuclear safeguards agreement. India will need to designate and put some of its nuclear power reactors under IAEA safeguards. Under the agreement, a total of 14 of India's 22 reactors are expected to come under the IAEA supervision by 2014 - the first ones as early as 2009. It would allow India to reprocess US-origin and other foreign-sourced nuclear fuel at a new national plant under IAEA safeguards. India will now proceed to NSG for a nod to allowing trade with a non-NPT country, followed by ratification from the US Congress, to finalize the agreement.

Today, India is largely excluded from trade in nuclear plant or materials, which has hampered its development of civil nuclear energy. India has a flourishing and largely indigenous nuclear power program and expects to have a nuclear capacity to produce 20,000 megawatts of electricity by 2020, subject to an opening of international trade. India is already in the process of constructing 6 power reactors, 4 of which are PHWRs and 2 pressurized water reactors through an agreement with Russia. Another 10 are planned and 9 proposed. According to a recent study by the Department of Atomic Energy, if we import nuclear reactors / fuel that would allow us to produce "additional" 20,000 megawatts of electricity by 2020 (that is, total 40,000 megawatts of electricity), the reprocessed plutonium to be used in FBRs would allow India to be self-sufficient in energy by 2050. Our 3-stage nuclear pogramme, however, would forge ahead unhindered.

Nuclear energy does not imply nuclear reactors and nuclear weapons alone! It is safe, environmental-friendly, and has innumerable applications in fields as diverse as health and medicine, industry, hydrology, food preservation, and agriculture. We may note that in the field of nuclear agriculture, the mutant groundnut seed developed at the Bhabha Atomic Research Centre (BARC), contribute to nearly 25 per cent of total ground-nut cultivation in the country. Similarly, the BARC developed mutant seeds of black gram (*urad*) contribute to 22 per cent of the national cultivation. In the state of Maharashtra, this percentage is as high as 95 per cent. In particular, so far as the future energy needs and economic development of our country are concerned, the agreement for nuclear energy would certainly prove to be extremely beneficial to our country in the decades to come.

(September 2008)

Destination Moon*

The Moon occupies a unique place in our daily life - be it poetry, literature, religion, or time-keeping. Indeed, our fascination with the Moon is as mysterious as the Moon itself. The Moon has the history of the early solar system etched on it. Understanding the Moon, therefore, provides a pathway to unravelling the early evolution of the solar system and that of the planet Earth. Indeed, the first ever scientific observation of the Moon was made by Galileo 400 years ago when he used his new invention - the telescope - to observe mountains and craters on the lunar surface. The era of space exploration began in 1960s; that is when observations of the Moon received a boost with fly-bys, orbiting and landing of space probes, and finally manned missions. Indeed, the fascination with the Moon continues to grow, as can be gauged from the fact that several countries – including India – have planned missions to the Moon in the near future. It now appears that a permanent human base on the Moon could be a reality in not too distant a future.

The first man-made object to fly by the Moon was the Soviet probe *Luna* 1 in January 1959. *Luna* 2 was the first probe to reach the lunar surface in September 1959, though the landing was hard. *Luna* 3 in October 1959 photographed the heavily pockmarked far-side of the Moon thus indicating significant differences between the two lunar hemispheres.

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* *Chandrayaan-1:* India's first mission to Moon was launched by ISRO on 22 October 2008. The editorial gives a historical perspective of other Moon missions, the importance of *Chandrayaan-1* and its goal.

It was in February 1966 that the first ever probe, *Luna* 9, soft-landed on the Moon and transmitted pictures of the lunar surface. The United States launched a series of parallel orbiting and landing missions in their *Ranger* and *Surveyor* series. Humans landed on the Moon on 20 July 1969, when Neil Armstrong, commander of the American Mission *Apollo* 11, set his foot on the surface of the Moon. The last man to walk on the Moon was Eugene Cernan during the *Apollo* 17 mission in December 1972.

The first robotic lunar rover to land on the Moon was the Soviet *Lunokhod* 1 in November 1970. Moon samples were brought back to Earth by the three Soviet missions (*Luna* 16, *Luna* 20 and *Luna* 24), and the US *Apollo* missions 11 through 17, except *Apollo* 13 which was forced to abort lunar landing. It was during this period that detailed analyses of dust and rocks brought back by *Apollo* and *Luna* missions were made in over 100 laboratories throughout the world including India. The studies also included lunar surface processes based on direct measurements using instruments placed on the Moon and also on-board lunar orbiting spacecraft.

After a lull for nearly two decades, there has been a renewed interest in lunar science. Imaging system on board American *Galileo* mission sent pictures of some of the unexplored regions of the Moon. *Clementine* and *Lunar Prospector* missions of USA carried out photogeologic and chemical mapping during 1991-98. Galileo identified a large impact basin, the South Pole- Aitken region on the far side of the Moon, which could not be recognized by the earlier missions because of its extremely subdued profile. In 1994, the *Clementine* mission photographed most of the lunar surface in ultraviolet, visible, near infrared and long wave infrared bands, thereby providing the first global data sets for lunar gravity, topography and multi spectral imaging. These results enabled global mineralogical mapping of the lunar surface. The *Lunar Prospector* carried a number of sophisticated instruments on board. Apart from preparing chemical maps of the Moon for elements like thorium, potassium, samarium, iron and aluminium, it also identified the presence of hydrogenbearing compounds, probably water, in the permanently shadowed north and south polar regions of the Moon.

In recent times, the European Space Agency launched European spacecraft *Smart* 1 in September 2003 to survey the lunar environment and create an X-ray map of the Moon. Japan has a lunar orbiter *Kaguya (Selene)* in flight, launched in September 2007. China has *Chang'e* 1 orbiter launched in October 2007. The *Lunar Reconnaissance Orbiter* of USA, scheduled for lift off in April 2009, is designed to map the surface of the Moon and characterize future landing sites in terms of terrain roughness, usable resources, and radiation environment with the ultimate goal of facilitating the return of humans to the Moon. India is all set to launch *Chandrayaan* 1 on 22 October 2008 for simultaneous chemical and mineralogical study of the lunar surface.

What is the *Chandrayaan* 1 mission aimed at, anyway? It is aimed at high-resolution remote sensing of the lunar surface in visible, near Infrared, low-energy X-rays and highenergy X-ray regions. In particular, it would help prepare a threedimensional atlas (with a high spatial and altitude resolution of 5-10m) of both near and far side of the Moon. Next, it intends to conduct chemical and mineralogical mapping of the entire lunar surface for distribution of elements such as magnesium, aluminum, silicon, calcium, iron and titanium with a spatial resolution of about 20 km and high atomic number elements such as radon, uranium and thorium with a spatial resolution of about 40 km. *Chandrayaan*1 will orbit the Moon at an altitude of 100 km and will carry eleven scientific instruments (payloads) on-board for this purpose. Five of them are Indian and other six are from European Space Agency (3), NASA (2) and Bulgarian Academy of Sciences (1). Two of the ESA instruments have Indian collaboration. *Chandrayaan* 1 will be launched by the upgraded Polar Satellite Launch Vehicle (PSLV) built by ISRO which has a lift off weight of 316 tonnes. It will take 5½ days to get to the Moon. *Chandrayaan 1* will weigh 1,034 kg at launch and 590 kg in the lunar orbit.

Surely, there are advantages and disadvantages associated with different types of missions, say, orbiter, lander and sample return missions. Orbiter missions have the advantage that they can cover the entire surface of the Moon and provide a global view. Landing and sample return missions provide only local information; but, they can resolve many important questions such as presence and dimension of core, presence of water, and bulk composition of the Moon. Much can be learnt if samples of some critical areas of the Moon can be brought to Earth for laboratory analysis. It is hence desirable that after the *Chandrayaan* 1 mission, the future missions land on the Moon with instruments, carry out experiments, and bring back samples from selected regions of the Moon for laboratory studies. This is why *Chandrayaan* 2, to be launched in 2011-12, will carry a lander / rover.

By simultaneous photogeological and chemical mapping, it would be possible to identify different geological parameters, which will test the hypothesis for the origin and early evolutionary history of the Moon, and help in determining the nature of the lunar crust. The hypothesis for the evolution of the Moon that is currently accepted is called the Giant Impact hypothesis. It suggests that a body about the size of Mars slammed into Earth shortly after Earth's formation, but only after it had formed an iron core. When the impact took place, it blasted a large part of the

Earth into space and the ejecta then began orbiting Earth. The material that blasted off the Earth later coalesced into the Moon. This hypothesis is able to explain (a) the missing Moon iron as most of the material blasted into space would have been depleted in iron after formation of Earth's core; (b) the similarity between Moon rocks and Earth because they came from the same place; and (c) the tilt of the Moon's as well as the Earth's orbit.

But, why this fascination with the Moon, anyway? NASA has embarked on an ambitious programme to establish a permanent base on the Moon; and from there eventually place humans on Mars. It would be of interest to note that the space-faring nations including Russia, China, Japan and India are also considering human flights to Moon and beyond in due course of time. Surely, it is necessary to know the topography and geology of the Moon for this purpose. Then, there is a possibility of water on lunar surface in the polar regions which are permanently shadowed from sunlight. Due to the very slight tilt (only 1.5°) of the Moon's axis, some of the deep craters, particularly near the polar regions never receive any light from the Sun – they are permanently in shadow and can act as permanent traps of water molecules. In such craters scientists expect to find water in frozen form. If there is water ice present on the Moon we will be able to rely on lunar ice, and there will be no need to transport water from the Earth. This is important for a costeffective lunar habitation. We may even look for new sources of energy, say tapping the reserves of He3 on the Moon, regarded as an ideal nuclear fuel, being non-polluting and having virtually no by-products.

Yet, how can we justify a poor country like India spending millions on mission to the Moon? Space science and technology has allowed a country like India to provide communications and remote sensing services to people in the remotest corners relatively cheaply and quickly. It is hard to imagine all this happening without investing in space technology. We could have a computer, but we would not be able to get on the internet. It may not be a quick-fix solution to raise people above the poverty line, or improve their health, but would certainly assure the nation of a prosperous future. It could give people a vision of future and help attract young people to study science and engineering. As Carl Sagan once said, it is possible to make a better life for everyone on Earth, and at the same time to reach for the planets and the stars.

(November 2008)

From Spyglasses to Space Telescopes*

Some four centuries ago, in 1609, Galileo Galilei pointed his homemade telescope at the Moon, the planets and the stars. And astronomy would never be the same again! However, Galileo did not invent the telescope! That credit goes to Hans Lippershey (or Lipperhey!), a relatively obscure Dutch-German spectacle maker. Interestingly, Lippershey never used his telescope to look at the stars. He believed that his new invention would mainly benefit seafarers and soldiers – and used for spying purposes. In 1608, Lippershey found that while viewing a distant object through combination of a convex and a concave lens, the object appeared closer and magnified. For this purpose, however, the two lenses had to be placed at just the right distance from each other. This is how the telescope was born – in the garb of a spyglass! But the Dutch government never granted him a patent since some other individuals also claimed the invention, especially Lippershey's competitor Sacharias Janssen. The dispute was never resolved. And to this day, the true origins of the telescope remain shrouded in mystery.

The news of this new invention and the device itself spread quickly throughout Europe. In Italy, Galileo heard about the telescope and decided to build his own. He deduced from the rumours how it must have been designed and constructed one of his own that made the object look three times bigger (that is, a telescope with a magnifying

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* International Astronomical Union declared the year 2009 as the International Year of Astronomy (IYA 2009), IYA 2009 marks the four hundredth anniversary of Galileo Galilei's first astronomical observations through a telescope.

power of 3) in June or July 1609. He presented an 8-power telescope to the Venetian Senate in August. The telescopes he made were of far superior quality than what were available commercially then. In October or November 1609, he turned his telescope with a magnifying power of 20 toward the Moon, the stars, the Milky Way, and the planets. And what he saw stirred great excitement in 17th century Europe.

True, Galileo was not the first to make a telescope. But, he was certainly the first to think of systematically using it to study the skies, rather than merely using it to spot ships at sea or observe troop movements in battle. The Moon was not a smooth perfect sphere as most astronomers and philosophers since Aristotle had believed. He observed that the Moon had great mountains and dark areas he called *maria* or "seas". He then observed the four satellites of Jupiter, called the "Galilean" Moons, and so named in his honour. He then turned his telescope towards Venus, and saw that like the Moon, Venus also shows phases – from crescent to disc to crescent. He concluded that like the Moon, Venus must not shine with its own light, but with the light reflected from the Sun. His observations seemed to fit with the revolutionary ideas of Copernicus as Kepler had modified them, with the Sun at the centre of the planetary system rather than the Earth. In 1610, Galileo published his observations in a book entitled *Sidereus Nuncius* (*The Starry Messenger*). Incidentally, the term telescope was coined by Prince Frederick Sesi during a demonstration by Galileo in Venice in 1611.

Until the beginning of the 17th century, people believed that the Earth was at the centre of the Universe. Scientists questioned this belief because the orbits of the planets were not consistent with such "geostatic" theories. It was not until the second half of the 17th century that the scientific community accepted that the Earth revolves around the Sun. The invention of the telescope gave the opportunity to establish that the Sun was at the centre of our solar system. The crescent of Venus could only be explained if the planet revolved around the Sun. Undoubtedly, the telescope is a striking example of how technology could help push the frontiers of science further ahead; and help improve our understanding of the natural phenomena. There is no gainsaying the fact that the invention of the telescope has had a profound influence on mankind ever since.

The telescopes used by Galileo were made with lenses that typically were only about 2.5 cm (1 inch) in diameter. Over the next 400 years, developments in technology made it possible to build ever larger telescopes with greater light-gathering capacity to detect even very faint objects. Mirrors replaced lenses as the main optical elements in telescopes. Incidentally, the first reflecting telescope was constructed by Isaac Newton in 1668 with an intention to overcome chromatic aberration, or the dispersion of light into different colours as it passed through the lenses in a refracting telescope. William Herschel made a telescope, using one tilted mirror around 1780. He built a number of large telescopes including a 1.2 m (48-inch) telescope constructed in 1789. The largest single telescope for visible and infrared light in the world today is the Great Canary Telescope situated at La Palma, Canary Islands, with the main mirror 10.4 m (410 inches) in diameter. There are plans afoot to build telescopes that are 3 to 5 times larger still.

Discoveries with telescopes from the 1600s through the 1800s laid the foundations for modern astronomy. Uranus was discovered in 1781 by William Herschel. The planet Neptune was discovered independently by the British astronomer John Couch Adams and the French astronomer Urbain Jean Joseph Leverrier in 1846. Next, the asteroids between the orbits of Mars and Jupiter were discovered. Newton's colleague Edmond Halley used the new theory of gravitation to calculate the orbits of comets. Based on his calculations, he noted that bright comets observed in 1531, 1607, and 1682 might well be the same comet orbiting the Sun every 76 years. He predicted that this comet would return around 1758. Although Halley had died by 1758, when the comet did indeed appear as he had predicted. It was given the name Halley's Comet. Telescopic studies of double stars, also known as binary star systems, provided the evidence that gravity is truly universal and that the same physical processes that we can study here on Earth can be applied to studies of distant objects, including stars. Observation through telescopes in 1838 helped measure distances to stars. In 1864 British astronomer Sir William Huggins showed that the pattern of dark lines in the spectrum of a star matched the patterns produced by elements known on the Earth. This showed that the physical processes that we study here on Earth can be used to study the whole universe. Study of spectra of stars provides information about their temperatures, masses, and their motions in space.

As the 20th century began, Albert Einstein advanced his General Theory of Relativity, which fundamentally changed our understanding of gravity, and the Universe. Einstein described gravitation as the curvature of space and time. One of the predictions of his theory was that the light should bend as it passed by a massive body like a star. In 1919, a team of astronomers led by British astronomer Sir Arthur Stanley Eddington used the occasion of a total solar eclipse to measure the deflection of starlight as it passed by the Sun and arrived at numbers that agreed with Einstein's predictions.

In 1923, American astronomer Edwin Hubble, using the largest telescope in existence at the time – the 2.5 m (100-

inch) Hooker telescope at the Mount Wilson Observatory – discovered that the Andromeda nebula was a vast distance from the Milky Way Galaxy, which had a diameter of 100,000 light years (a light year is the distance light travels in one year at the speed of 300,000 km/s); and so must be a separate galaxy. His studies of distant galaxies revealed that the universe was not static, as had been previously believed, but was expanding in size.

The second half of 20th century was truly a golden age for astronomy. Advances in technology expanded our vision by enabling us to look at the heavens in different parts of the electromagnetic spectrum and not just restrict our observations to the visible part of the spectrum alone. We cannot detect these signals with our senses, but must use electronic equipment. In a radio telescope, radio waves from celestial sources are reflected by a metallic surface and are brought to a focus, then sent to a receiver, where they can be recorded and analyzed. Radio astronomy proved to be instrumental in verifying the Big Bang theory of the origin of the Universe.

New windows on the Universe opened up with the ability to launch spacecraft. Astronomical objects not only give off radio waves and light at the frequencies our eyes are sensitive to, but also emit electromagnetic radiation ranging from high-energy gamma rays and X-rays, to infrared or heat radiation. Much of this electromagnetic radiation is absorbed by Earth's atmosphere and hence does not reach the ground. Technology again made it possible to launch telescopes above Earth's atmosphere to observe the astronomical objects in different types of electromagnetic radiation.

Beginning with the last quarter of the 20th century, many spacecraft designed to exploit the advantages of being outside Earth's atmosphere have been launched. The Chandra X-ray Observatory, the Spitzer Space Telescope, and the Hubble Space Telescope (HST) were particularly powerful. Turbulence in the Earth's atmosphere blurs astronomical images. Because the Hubble Space Telescope is unaffected by this blurring, it can take extremely sharp images and has given astronomers both scientifically important and stunningly beautiful images of planets, star clusters, and galaxies. Spacecraft have been sent to orbit all of the planets. Pluto (which was formerly classified as a planet, then a dwarf planet, and yet again classified as plutoid) has not yet been visited by a spacecraft. Pluto was discovered by American astronomer Clyde Tombaugh in 1930. *New Horizons*, a spacecraft launched in 2006 is expected to rendezvous with Pluto in 2015. In particular, India's Moon probe *Chandrayaan*-1 has already entered the lunar orbit with an aim to observe it in the visible, near infrared, low energy X-rays and high-energy X-ray regions. India is also poised to launch *Astrosat*, a satellite to observe and study astronomical phenomena, in 2011.

Today we know that Milky Way, our own galaxy, is only one of the billions of galaxies in the Universe. Astronomers have also verified that black holes exist in large numbers, and that our Sun is only an ordinary star in our galaxy with a family of planets, comets and asteroids. Now, we have discovered that our solar system is not the only one. Astronomers have found some 200 planets orbiting other stars. Surely, we have come a long way since Galileo observed the heavens through his tiny telescope in 1609. Now telescopes on the ground and in space explore the Universe 24 hours a day, across all wavelengths of the electromagnetic spectrum.

It is desirable that the citizens of the world rediscover their place in the Universe through the day and night time sky, and thereby engage a personal sense of wonder and discovery. It is important that all human beings realise the impact of astronomy and basic sciences on our daily lives, and understand better how scientific knowledge can contribute to a more equitable and peaceful society. This is why the United Nations in its 62nd General Assembly proclaimed 2009 as the International Year of Astronomy (IYA 2009), with the central theme “The Universe, Yours to Discover”.

With the International Year of Astronomy 2009 (IYA 2009) we celebrate a momentous event, the first astronomical use of a telescope by Galileo, an invention that initiated 400 years of incredible astronomical discoveries; and pay homage to one of the greatest of scientists. Indeed, Galileo’s telescope triggered a scientific revolution which has profoundly affected our world view. “Pure logical thinking”, Einstein once wrote, “cannot yield us any knowledge of the empirical world; all knowledge of reality starts from experience and ends in it. Because Galileo saw this, and particularly he drummed it into the scientific world, he is the father of modern physics – indeed of modern science altogether.”

In each participating country, the IYA 2009 activities will take place locally, regionally and nationally. Vigyan Prasar has chalked out an ambitious campaign with production of a 52-episode radio serial in 19 Indian languages including English, to be broadcast from over 100 stations of All India Radio, and a 26-episode television serial on astronomy along with publications and development of a variety of software; and training programmes at different levels. An important part of the campaign would be activities built around the total solar eclipse of 22 July 2009 which would be visible in India. While celebrating this event we should be guided by the spirit of adventure and questioning that had motivated Galileo, says Professor Jayant V. Narlikar.

(December 2008)

Living with Cancer

Cancer occurs in most species of animals and in many kinds of plants, as well as in human beings; and is a leading cause of death in many countries. It accounted for 7.9 million deaths (13 per cent of all deaths) in 2007, out of nearly 60 million deaths worldwide. True, cancer strikes people of all ages, but it especially strikes the middle-aged and the elderly. Further, it occurs about equally among men and women, and can attack any part of the body. The parts that most often get affected are the skin, the digestive organs, the lungs and the female breasts. Further, most kinds of cancer are fatal without proper treatment.

More than 70 per cent of all cancer deaths occur in low and middle income countries. The five most common types of cancer that kill men (in order of frequency) worldwide are the cancer of lung, stomach, liver, colorectal (affecting the colon and the rectum) and oesophagus (gullet or the passage between the pharynx and the stomach). The five most common types of cancer that kill women (in the order of frequency) are the cancer of breast, lung, stomach, colorectal and cervical. Tobacco use is the single largest preventable cause of cancer in the world. Further, one fifth of all cancers worldwide are caused by a chronic infection. For example, human papilloma virus (HPV) causes cervical cancer and hepatitis B virus (HBV) causes liver cancer.

But, how does cancer start, anyway? Cancer is often triggered by carcinogens (cancer causing agents) such as tobacco smoke, and industrial chemicals such as arsenic, asbestos, and some oil and coal products. Certain viruses also can trigger cancer. Inheritance of faulty genes (sections of DNA) could also play a part. Carcinogens damage specific genes known as oncogenes. Incidentally, oncogenes regulate vital processes such as cell division and growth, repair of damaged genes, and the ability of faulty cells to self-destruct. Indeed, most damaged genes are repaired as part of normal cell metabolism. But, some cells can get gradually altered, or mutated, by regular exposure to carcinogenic agents and thus fail to carry out their normal functions. Damage to oncogenes may force them to make altered versions of their chemicals within the cell. Thus, they work like molecular *locks* or *keys*, and *trick* the cell into functioning abnormally. Eventually, the cell may become cancerous and divide into two cells. These cells further divide in an uncontrolled manner retaining the cancerous changes. The total cell number doubles on each division. A solid tumour becomes detectable after twenty-five to thirty doublings, when it contains about a billion cells. The doubling time may range from one month to even two years depending on tumour type. All this from just *one* cell that undergoes cancerous changes and eventually culminates into a tumour!

Incidentally, cancer is a generic term used for a large group of diseases that can affect any part of the body. Malignant tumours and neoplasms are the other terms employed for cancer. One defining feature of cancer is the rapid creation of abnormal cells that grow beyond their usual boundaries. These cells can then invade adjoining parts of the body and even travel to other organs, causing secondary growths or tumours. This process is referred to as metastasis. Metastases are the major cause of death from cancer. There are more than 100 identifiable forms of cancer that can be classified into three main categories. Carcinoma, which is the cancer of the epithelial tissue, affects the skin and the linings of the internal organs. Next, sarcoma is cancer of the connective tissue, such as cartilage, muscle and bone. Finally, 'fluid' cancer like leukaemia and lymphoma affects the blood stream and the lymphatic system. Sometimes, sarcoma is included in the third category since blood and lymph are forms of connective tissue. Leukaemia, sometimes called blood cancer, incidentally is a disease of the bone marrow, where blood cells are produced.

How is cancer treated? The three main methods of treating cancer include surgery, radiation therapy or radiotherapy, and drug therapy or chemotherapy. In several cases, treatment consists of combination of two, or even all the three methods, a procedure called combination therapy. Radiation from X-rays or radioactive substances kills cancerous cells as well as normal cells. Hence care must be taken to administer radiation doses that do not endanger life. Chemotherapy is particularly effective against leukaemia or lymphoma, but is also used against other forms of cancer. These anticancer drugs also function like radiation – they too kill normal cells and have side effects ranging from nausea and hair loss to high blood pressure.

Indeed, a third of cancers could be cured if detected early and treated adequately. All patients in need of pain relief from cancer could be helped if current knowledge about pain control and palliative care were applied. 30 per cent of cancers could be prevented by not using tobacco, having a healthy diet, being physically active, and preventing infections that may cause cancer. Earlier, the methods of treatment gave little hope for recovery. But, of late, the methods of diagnosing and treating the disease have greatly improved. Today, about one-third of patients treated for cancer recover or live much longer than they would without the treatment. The research over the last few decades, however, has given us new insights, and has shown that it may not be possible to develop a simple cure for the disease. In other words, our dream of 'conquering this dreaded disease' after all may not be quite realisable. Rather, we shall have to learn to live with the enemy!

With the advent of genomics (the branch of genetics that studies organisms in terms of their full DNA sequences), biologists are starting to learn why cancer is such a wily foe. To begin with, it is necessary to realise that mutations that can turn cells cancerous and drive a tumour's growth take place in many diverse ways. It is this enormous diversity of mutations that gives these cancerous cells endless opportunities to outwit our defence mechanisms. Hence, by tracking these mutations, and targeting each of them with suitable drugs, we may be able to bring cancer under control. It may even be possible to harness the human immune system, which is capable of mounting its own targeted responses, to keep the tumours in check.

Of late, biologists have been collecting new information about the molecular pathways (mechanisms) that drive cancer. This has led them to question the traditional method of classifying the tumours according to where they appear in the body. They are realising that what matters are the *particular* mutations which make the cells in a tumour grow in an uncontrollable fashion. Two patients with cancers in completely different tissues, but triggered by the same mutation, may have more in common with each other than patients with tumours in the same organ but caused by different molecular mechanisms. Conversely, two patients with superficially the same type of cancer may have very different prognoses, depending on the underlying mutations involved.

Once we throw away the notion that cancer is an anatomically defined disease and focus on the molecular abnormalities, the entire perception and approach for treating cancer changes. Conventional chemotherapy and radiotherapy work by being extremely toxic to dividing cells. While these treatments damage the fast growing tumour cells, they also have an adverse effect elsewhere in the body. The current trend is to get away from this model and understand the *changes* that occur in cancer that differentiate it from normal cells. We could then come up with drugs that specifically target those changes according to a recent report in the *New Scientist* (25 October 2008). It would then be possible to transform cancer from a lethal disease into a chronic condition that people may be able to live with almost indefinitely. Treatments may probably require cocktails of targeted drugs that will have to be adjusted as tumours mutate. We may note that this approach is similar to the treatment of HIV, where a cocktail of anti-retroviral drugs can slow down the replication of the virus thereby enabling people to live with the infection until old age. If they develop resistance to one drug, they are moved to another one. This is how HIV has turned from a lethal condition to a chronic condition.

This new perspective has provided fertile ground for the growth of new classes of cancer therapies. Newer drugs are more like smart bombs, though expensive. Some target communication signals with the malignant cells, some cut off supply lines by interfering with the growth of blood vessels around a tumour, and others block the chemical agents that enable tumours to expand into new territory. These more targeted therapies tend to focus on frantically proliferating cancer cells while leaving healthy cells in tact. Drugs like Avastin inhibit the formation of new blood vessels around cancer cells starving them of nourishment. Signal blockers like Everolimus interrupt communication among enzymes that regulate growth and development of a cancerous cell. Hormone blockers like Tamoxifen, useful in certain types of breast cancer, keep cells from dividing by binding to oestrogen (a general term for female sex hormones) receptors. Growth-factor inhibitors like Herceptin block a cancer cell's link to crucial proteins that help it divide and grow. However, none of these advances mean that living with cancer is easy. A certain number of patients do not respond to any of the current treatments. Some types of cancer, especially, pancreatic, ovarian and stomach, continue to have high mortality rate. Side effects, however, remain an issue, despite the anti-nausea medications now being very good.

Despite the progress in the cancer therapy, it is imperative that we put in efforts to reduce the burden of cancer. It can be done by implementing evidencebased strategies for cancer prevention, early detection of cancer and management of patients with cancer. The key risk factors for cancer are tobacco use, being overweight or obese, low fruit and vegetable intake, physical inactivity, alcohol use, sexually transmitted infections such as HIV and HPV, urban air pollution, and indoor smoke from household use of solid fuels. Prevention strategies would obviously include avoidance of these risk factors. Next, it is necessary to educate and help people recognise early signs of cancer and seek prompt medical attention for symptoms, which might include lumps, sores, persistent indigestion, persistent cough, and so on. Education is also required to identify cancer early before signs are recognisable. We may then be able to live with the enemy, if not exterminate it.

(January 2009)

Survival of a Theory through Natural Selection*

In 1832, Charles Darwin, twenty four years old and a British naturalist on HMS *Beagle*, a ship sent by the Admiralty in London on a surveying voyage round the world, came to a forest outside Rio de Janeiro in Brazil. In one day, in one small area, he collected sixtyeight different species of small beetle. That there should be such a variety of species of one kind of creature astounded him. The conventional view at his time was all species were immutable and that each had been individually and separately created by God. Darwin was far from being an atheist. He had taken a degree in divinity from Cambridge, but was deeply puzzled by the variety of forms.

During the next three years, the *Beagle* sailed down the east coast of South America, then sailed along the west coast, and came north again up the coast of Chile. The expedition then sailed out into the Pacific, and came to the lonely archipelago of the Galapagos some 1,000 kilometres from the mainland. Here, his question of the creation of the species recurred, for it was in these islands that he found fresh variety. He was fascinated to find that the Galapagos animals bore a general resemblance to those he had seen on the mainland, but differed from them in detail.

The suspicion grew in Darwin's mind that species were not fixed for ever. May be, one could change into another. It

* Year 2009 marks 200th year of Darwin's birth and 150th anniversary of publication of *Origin of Species*. The editorial provides historical account of Darwin's surveying voyage round the world and insight of natural selection.

could be that birds and reptiles from continental South America had reached Galapagos, say on the rafts of vegetation that float down the river and out to sea. Once they reached the Galapagos, they had changed, generation after generation, to suit their new homes until they became present species. Certainly, the idea was not a new one. Many others before Darwin had suggested that all life on Earth was interrelated. However, his revolutionary insight was to perceive the mechanisms that brought these changes about.

His argument went like this. All individuals of the same species are not identical. As an example, consider an animal which obtains a dark colouring as a result of a mutation. If it lives in a dark environment, potential predators will have a harder time spotting it than they have spotting its lighter-coloured mates. After a great number of generations, there will be more and more dark-coloured animals as the light-coloured ones get eaten more often. So the best fitted to their surroundings, will be able to transmit their characteristics to their offspring. And so one species will have given rise to another.

However, this concept did not become clear to Darwin until long after he left Galapagos. For twenty-five years he painstakingly gathered evidence to support it. Not until 1859 did he publish it. He called the book in which he set out his theory, *The Origin of Species by Means of Natural Selection or the Preservation of Favoured Races in the Struggle for Life*. Since that time, the theory of natural selection has been debated and tested, refined and elaborated. Later discoveries about genetics, molecular biology, population dynamics, and behaviour have given it new dimensions. It remains the key to our understanding of the natural world and it enables us to recognise that life has a long and continuous history during which organisms – plants and animals – have changed, generation after generation, in different parts of the world.

How is it possible for one species to give rise to more than one subsequent species? One process by which this can occur is through the division of a population into two or more smaller populations by a geographical barrier. If the environments of the respective populations differ, different traits will be selected for in each, and the evolution of these populations will follow different courses. As the two groups become isolated from each other, they would stop sharing genes, and eventually genetic differences would increase until members of the groups can no longer interbreed. At this point, they have become separate species and the speciation (evolution of a new species) is complete. Through time, these two species might give rise to new species, and so on through millennia. Another process that may give rise to speciation is climate change.

Origin of Species attracted enormous attention to the issue of natural derivation of all species from one, or few, original living forms, or "Evolution" as it is called. In 1871, Darwin came up with *The Descent of Man, and Selection in Relation to Sex*, in which he supported the idea that humans descended from pre-human creatures with considerable evidence from his research. Surely, this was the most troubling point for most people. How could humans descend from a non-human ancestor? Most people, however, accepted Darwin's theory of evolution by natural selection by the end of the 19th century, except for those who opposed evolution as antithetical to the biblical story of creation. It was around the same time when *Origin of Species* was published that Gregor Mendel discovered the laws of heredity. Working with peas, he found that for each trait, an offspring inherited factors from both the parents equally; and that those factors remain distinct and can in turn be passed on to subsequent offspring. This meant that natural selection would have much more time to operate on any variation in trait.

The term evolution refers both to fact and theory. When used to describe a fact, it may refer to the observations on one species of organisms changing into another species over a period of time. When used to describe a theory, it refers to an explanation about how and why the process of evolution takes place. The theory of evolution incorporates both Darwin's theory of natural selection and Mendel's principles of genetics.

Natural selection implies greater reproductive success among particular members of a species which arises from genetically determined characteristics. Such characteristics confer an advantage in a particular environment. One species evolves into another as a result of genetic mutations (changes) that are inherited by the new species. Some of these mutations are more likely to spread and persist in a gene pool (species) than others. If such mutations result in a survival advantage for organisms that possess them, then they are more likely to spread and persist. However, if such mutations do not result in a survival advantage, or if they result in a survival disadvantage, they are less likely to spread and persist – they would rather perish and become extinct. *Genetic mutation is random, but natural selection is not.* Natural selection tests the combination of genes represented in the members of a species and allows proliferation of those that confer the greatest ability to survive and reproduce.

Evolution by natural selection is a continuing process – it operates even today. For example, the microorganisms that cause malaria, tuberculosis and many other diseases have over the years developed a highly increased resistance to antibiotics and drugs which were used to treat them in the past. Similarly, many hundreds of insect species and other agricultural pests have evolved resistance to the pesticides used to combat them.

Unfortunately, Mendel's work did not become widely known until it was rediscovered by Hugo de Vries and William Bateson in 1900. Yet it took about four decades for biologists from various specialties to build consensus around the so called modern synthesis combining Darwin's notion of natural selection with the science of genetics. Since 1940s, that has been the evolutionary theory adopted by the majority of biologists. From the mid-1960s new approaches have emerged to the study of biological evolution employing new tools and concepts of evolutionary ecology, palaeontology, and molecular biology. The growing genomic information should bring us closer to the understanding of the key steps in evolution – the origin of species. Surely every bit of biodiversity is invaluable. We never know which one would trigger the next innovation. There is no gainsaying the fact that Darwin's evolutionary theory has survived through a process of natural selection!

The year 2009 is unique. It marks the 400th anniversary of the first astronomical use of telescope by Galileo that initiated incredible astronomical discoveries that triggered a scientific revolution profoundly affecting our world view. It also marks 200th year of Darwin's birth and 150th anniversary of the publication of *Origin of Species*. 2009 has also been designated as the Darwin Year. Galileo began the process that showed us we inhabit a tiny speck, orbiting a tiny speck among billions of specks in a galaxy. Darwin showed us we are animals occupying a tiny limb on the tree of life and needing no divine spark to account for our many adaptations, says Daniel Dennett of Tufts University, Boston, in a recent issue of *New Scientist* (20 December 2008). Galileo saw the value of the telescope, built the best one then in the world and made careful observations. Ultimately he used it to confirm what Copernicus had earlier suggested. Darwin spent years travelling and collecting specimens before he had to sit down and think about what it all meant! Who has the greater edge – Galileo or Darwin? I believe it's a draw! We must celebrate the Darwin Year with as much fervour as the International Year of Astronomy 2009.

(February 2009)

Preserving Astronomical Heritage

The World Heritage List of UNESCO includes 878 sites forming part of the cultural and natural heritage, and considered as having 'outstanding universal value'. The Angkor Wat temples in Cambodia, the Acropolis in Athens, Ajanta and Ellora caves in India, and the archaeological ruins of Mohenjo-daro are among the 679 *cultural* sites protected by UNESCO. The List also includes 174 *natural* sites, such as the Great Barrier Reef in Australia, Kaziranga National Park in Assam, Yellowstone National Park in the USA, and the Serengeti National Park in Tanzania, to name a few. The remaining 25 sites are *mixed* sites that are considered outstanding from both cultural and natural standpoint, such as the historic sanctuary of Machu Picchu in Peru.

Sites like the monuments of Mahabalipuram, the monuments at Hampi - the last capital of the last great Hindu kingdom of Vijayanagara, or Fatehpur Sikri are some of the extraordinary creative masterpieces of the lost cultural traditions. These are the places where human communities lived and flourished for thousands of years, and died. What is more, each site stands out as a window to the past and a source of inspiration for people across the world to peep into the ancient civilizations that existed there, and the beliefs and practices followed by those people.

However, one aspect of our cultural heritage - astronomy - is woefully underrepresented in the World Heritage List. In fact, several beliefs and practices in the ancient days had their origins in the astronomical phenomena - the motion of the Sun and the Moon through the zodiac, stars and constellations seen during different seasons, equinoxes, eclipses; and so on. Indeed, the cosmos has captivated the imagination of civilisations through the ages. The efforts of those cultures to understand or interpret what they saw in the sky are often reflected in their architecture, petroglyphs (carvings on rock made by prehistoric people), and other cultural representations. This is how astronomy has had a significant influence on the architecture of ancient temples and tombs. Needless to say, we cannot ignore the relationship of these monuments to the sky if we want to learn and appreciate the beliefs and practices reflected in their architecture.

No doubt, a few ancient sites and monuments with link to the sky do figure into the World Heritage List, but the criterion used for their selection was their architectural and cultural significance - not their relation to astronomy. One such example is the Stonehenge in Wiltshire, United Kingdom. The main axis of the monument faces the direction over the horizon where the Sun rises on the morning of the summer solstice, the longest day of the year, and sets on the day of the winter solstice, the shortest day of the year. Then, there is the Neolithic passage tomb of Newgrange in Ireland. It is so aligned that the Sun shines in only for a few minutes after sunrise on the day of the winter solstice. At Chaco Canyon in New Mexico, southwestern USA, at noon on the summer solstice, a single sliver of sunlight - dubbed as “Sun dagger” - appears near the top of a spiral carved on a rock and slices its way down through the very centre, cutting the spiral in half before leaving it in shadow once again. On the winter solstice, two daggers of light appear during which they exactly frame the spiral! The Konark Sun Temple in Orissa featuring in the World Heritage List is one such site. The magnificent temple is in the form of the Sun’s chariot drawn by seven horses marking the seven days of the week. The 24 huge wheels, magnificently carved and decorated, mark the hours of the day. The idol of the Sun God no longer exists today. It is, however, claimed that on days close to the equinoxes the Sun would shine at dawn or sunset on the Sun God in the temple.

It is a matter of grave concern that there have never been any guidelines for nominating World Heritage Sites based on their relationship to astronomy. As a result, many such sites could be susceptible to neglect and damage. It is with this concern that UNESCO is now encouraging the member countries to put forward nominations for astronomical sites. The objective of this Astronomy and World Heritage thematic initiative is to establish a link between science and culture on the basis of research aimed at acknowledging the cultural and scientific values of the sites connected with astronomy. The identification, safeguarding and promotion of these sites are the three lines of action for the implementation of this programme. What is important is the fact that during 2009, the International Astronomical Union would be working with UNESCO to come up with specific criteria for judging the merit of the proposed sites. This initiative would provide us with an opportunity to identify sites related to astronomy located around the world, and to save them from progressive deterioration. Surely, it is a fitting task for the International Year of Astronomy 2009, celebrating the 400 years of the first use of the telescope by Galileo for observing the sky; and the publication of Johannes Kepler's *Astronomia Nova* describing the first and the second law of the planetary motions.

Astronomy and World Heritage initiative of UNESCO will include sites related to history of modern astronomy in addition to the prehistoric sites. It will also include observatories, instruments and places where astronomical discoveries were made. No doubt, this is an important part of science heritage in general, and astronomy in particular, which is not adequately represented on the World Heritage

List. The 15th century observatory of Ulugh Beg in Samarkand, Uzbekistan, the 18th century observatory of St. Petersburg in Russia, and the old Royal observatory in Greenwich are a few examples that do appear on the World Heritage List, but they are only parts of sites with broader significance.

Two of the five surviving astronomical observatories built by Maharaja Jai Singh II at Delhi and Jaipur consisting of fourteen major geometric devices for measuring time, predicting eclipses, tracking stars, ascertaining the declinations of planets, and determining the celestial altitudes and related ephemeris, could be strong candidates for the nomination of the Astronomy World Heritage sites. Other potential candidates may include the ruins of the Vijayanagara Empire, Sun temple at Modhera, Gujarat, the Gavi Gangadhareshwara temple at Bangalore, and so on.

Hopefully, the initiative of UNESCO to identify Astronomy World Heritage sites would provide impetus for research in a not so well-known field of archaeoastronomy in India. Incidentally, archaeoastronomy is the study of how people in the past understood the phenomena in the sky, how they made use of those phenomena, and what role the sky played in their culture. For example, in North Karnataka and Hyderabad regions, there are some 40 sites of stone alignments suggesting their use as sight-lines for monitoring the sunrises and sunsets over the horizon to estimate and predict the seasons and the passage of years. In particular, at Hanamsagar in Belgaum district of Karnataka, a typical stone arrangement shows direction of summer and winter solstices. Already, in a first, a team from the Tata Institute of Fundamental Research, Mumbai, has undertaken an archaeoastronomical project to study India's ancient Indus Valley Civilization sites from a purely astronomical perspective.

The sky is our common and universal heritage, and it forms an integral part of the total environment that is perceived by mankind. Hence, interpretation of the sky as a theme in World Heritage is a logical step towards taking into consideration the relationship between mankind and his environment. Needless to say, sites relating to astronomy are a tribute to the complexity and diversity of ways in which people rationalised the cosmos and framed their actions in accordance with that understanding. This includes - but is by no means restricted to - the development of modern scientific astronomy. Astronomical knowledge and its role within human culture define the outstanding universal value of these sites. These material testimonies of astronomy, found in all geographical regions, span all periods from prehistory to today.

"Every human culture has a sky, and strives to interpret what people perceive there", says Clive Ruggles, emeritus professor of archaeoastronomy at the University of Leicester, UK, and chair of the IAU's working group on astronomy and world heritage, in a recent issue of *New Scientist* (17 January 2009). The understanding people develop by observing the sky forms a vital part of their knowledge concerning the cosmos and their place within it. Seen from this standpoint, astronomy is not just a modern science, rather it is a reflection of how all peoples - past and present, see themselves in relation to the universe. In today's world, where globalisation of human culture moves at breakneck pace, safeguarding our astronomical heritage is vital for saving the fragile aspects of our common cultural heritage - before they are lost forever.

(March 2009)

In Search of Other Earths*

Are we alone? Humans have pondered over this question for centuries. Scholars have speculated, and continue to speculate, that Earth-like planets must exist and harbour life – at least some form of life - elsewhere in the universe. Considering that there are 100 billion suns in our galaxy, and our Galaxy is only one of a 100 billion other galaxies; and that the cosmos is much older than the solar system, it is quite likely that life could have started elsewhere much earlier than on Earth.

It is interesting to note that in recent years the discovery of organic molecules and amino acids in molecular clouds deep in space, meteorites and comets suggest that at least low-level life-forms, given the right place, may be quite common in the universe. Further, life appears to be much more robust than previously thought. Bacteria have been discovered several kilometres below the Earth's surface that thrive only on the minerals in the rocks. Deep in ocean, life-forms have been found feeding on the sulphur spewing from hot, almost boiling vents and at great pressures. We could thus expect life forms that could have evolved even in completely different ways depending on the physical conditions existing on the planets orbiting other stars.

Ever since the suggestion by Philip Morrison and Giuseppe Cocconi in 1959 that radio waves could be used

* NASA launched *Kepler Space Telescope* on 7 March 2009. It is expected that the unprecedented sensitivity and unique positioning of 'Kepler' would enable it to locate Earth-sized planets in the habitable zone of their stars.

for detecting signals from our likely cosmic counterparts, and the very first experiment run by astronomer Frank Drake in 1960 at the Green Bank radio telescope facility in West Virginia, USA, the search for extraterrestrial intelligence (SETI) has continued in full swing. Today it is an international effort by several groups. SETI involves looking for potentially artificial signals amongst the myriad of signals coming from outer space. Indeed, it is like trying to find a tiny *intelligent* needle in a vast cosmic haystack. SETI does not send signals into space; it only listens. Intelligent life, if it were interested in communicating with us, would have to send signals which are distinguishable from other sources, and the signals would have to be *deliberately* beamed towards us.

Could Earth-like planets exist? The search for extraterrestrial life received a boost with construction of large telescopes, progress in imaging technology, and Earthorbiting space telescopes during the past two decades. With the discovery of about 350 planets orbiting other stars since 1995, the centuries-old quest for other worlds like our Earth has been rejuvenated. Indeed, several stars have been discovered with planets orbiting them. Our solar system is thus not unique. *Exoplanets*, as they are called, appear to be common in our galactic neighbourhood. However, the ones discovered so far are mostly gas giants with characteristics similar to Jupiter and Neptune. If we could discover smaller, terrestrial planets like Mars and Earth, there is greater chance that we may detect life on them. Indeed terrestrial planets are extremely difficult to detect due to their small size and proximity to the bright stars they orbit.

Only recently has the *Convection Rotation and Planetary Transits Space Telescope* (*CoRoT*), launched by European Space Agency in 2006, found the smallest terrestrial planet ever detected outside the solar system. The amazing planet is less than twice the size of Earth and orbits a Sunlike star. Its temperature is so high that it is possibly covered in lava or water vapour. It further strengthens our belief in possible existence of Earth-like planets and life in other regions of the universe. Over the next 15 years, NASA is embarking on a bold series of missions to find and characterise new worlds. These missions will have the most sensitive instruments ever built, and will be capable of reaching beyond the bounds of our own solar system.

How do we detect the exoplanets, anyway? Planets found around the nearby stars have been discovered only indirectly, never seen. This is essentially because planets do not produce any light of their own (except when young). Next, they are at an enormous distance from us; and they are lost in the blinding glare of their parent stars. If so, how could we detect them? One way is to precisely measure the radial velocity or change of position of stars. A star with a single planet both move about their common centre of mass. If we are observing the spectrum of the star, it appears to shift towards the red end when it is moving away from us and towards the blue end when it is moving towards us as a result of Doppler Effect. This tells us the extent of the star's movement induced by the *planet's* gravitational tug. From that information, one can deduce the planet's mass and orbit. In a method called the astrometric method, the slight motion of the star caused by the orbiting planet is accurately measured. In this case, however, astronomers search for the tiny displacements of the stars on the sky. Yet another method, the transit method, utilises the fact that if a planet passes directly between a star and an observer's line of sight, it blocks out a tiny portion of the star's light, thus reducing its apparent brightness. Many of us would immediately recall the phenomenon of Mercury or Venus transit, and how the planet blocks the part of the Sun during its passage across the disc of the Sun. Sensitive instruments can detect this periodic dip in the brightness. Finally, in the novel method of gravitational microlensing, the use is made of the fact that when a planet happens to pass in front of a distant star along our line of sight, the planet's gravity will behave like a lens, bending the light coming from the distant star. This *lensing* effect focusses the light rays and causes a temporary sharp increase in brightness and change of the apparent position of the distant star. Direct imaging of the planet, however, is a difficult proposition at present, but may become possible in the days to come.

If our goal is to find planets with evidence of life, those discovered so far certainly do not make good candidates. Many of them get too hot or too cold and hence cannot support life. Many have highly elliptical orbits, or are too close to the parent stars. For example, the right location, or the *habitable zone*, in our solar system would be between Venus and Mars. How shall we know if a planet could support life? First, we must look for the signs of liquid water. Next, we must look for the evidence of oxygen, especially ozone (O_3) produced by plants and algae, and the signs of biological activity in the form of methane (CH_4), which is produced by living organisms. Further, we shall need to analyse the reflected light from the planet to see if the planet has an atmosphere.

Clues for alien Earths; that is, small, rocky planets orbiting at the right distance to be not so hot that water boils and not so cold that it stays frozen, have been hard to come by. This is so because surveys have not been sensitive enough to find many such planets. This should change with the *Kepler Space Telescope* launched by NASA on 7 March 2009. Its unique positioning in the solar system and unprecedented sensitivity imply that for the first time we will be able to see Earth-sized planets in the habitable zone of their stars, that is, the region where the temperature on the planet should be right for liquid water to exist at its surface.

Indeed, the vast majority of exoplanets were discovered by the radial velocity technique which is not sensitive enough to detect planets as small as the Earth. However, *Kepler* will use the method of planet transits - a far more reliable method. By monitoring more than 1,00,000 stars for periodic dips in brightness, it would spot when a planet passes in front of them. *Kepler* would be in its own orbit around the Sun far away from the Earth's orbit, and hence the Earth would not cause any interference with observations. The most important aspect is the fact that *Kepler* would observe the same part of the sky uninterrupted for the entire mission of about three-and-a-half years. *Kepler* would observe at least three transits of any planets it finds that are in one-year orbits, like Earth's. This is necessary for confirming the recurrence of transit events at a precise interval, thereby ruling out undesirable factors such as fluctuations in the brightness of the star itself. Further, *Kepler* will also be much more sensitive than *CoRoT*. It will have an effective light-gathering aperture of 95 centimetres, compared with *CoRoT*'s 27 centimetres, which should allow it to see planets as small as half the size of the Earth, or about the width of Mars.

How many Earth-sized planets will *Kepler* find? No one knows! But, whatever *Kepler* discovers, would certainly guide the next stage of planet-hunting. If Earth-like planets are common, then at least a few may be orbiting stars near enough. If so, future missions could scrutinise them for evidence of oxygen and other clues that could hint at the presence of life. Incidentally, NASA and ESA have been working on missions called *Terrestrial Planet Finder* and *Darwin*, respectively. These missions aim to observe the faint glimmer from exoplanets in the habitable zone of their stars, and look for signatures that would hint at the presence of life. There is no gainsaying the fact that the success of these missions rests on the *Kepler* Mission. But if *Kepler* finds that rocky planets in the habitable zone are rare, then there may not be many planets close to us to observe in detail.

Earlier our planet was believed to be at the centre of the universe. Copernicus displaced it, and ever since, our place in the cosmos has steadily become less and less privileged! Earth was just one planet out of many. "Now we are also seeing that our solar system is not necessarily particularly special; we know of hundreds of planets around other stars", says Jonathan Lunine of the University of Arizona, Tucson, who chaired a committee called the Exoplanet Task Force that produced a report last year on alien worlds.

Is anybody out there?

(April 2009)

The Web Turns 20

13 March 2009 (Friday) marked the 20th anniversary of the World Wide Web. In March 1989, Tim Berners-Lee, then a little-known computer scientist, wrote a proposal entitled "Information Management: A Proposal". He was then working as a consultant at CERN (European Organisation for Nuclear Research - now called the European Laboratory for Particle Physics), near Geneva. Mike Sendall, his supervisor, described it as "vague, but exciting", but, later gave it the go ahead, although it took a good year or two to get off the ground. It was this proposal that paved the way for the World Wide Web and the consequent information explosion we are familiar with today.

Indeed, it is difficult to think of life without access to Internet! Be it access to or sharing of data files and documents, e-mail, banking, chat, news, job hunting, product info, shopping on the net, entertainment, contests, rail or air tickets, downloading software or games, matrimonial alliance and so on - the list is growing! The Internet is the transport vehicle for the information stored in files or documents of another computer. It would, however, be a misstatement when one says, "I found the information on the Internet!" In fact, what one means is that the document was found through or using the Internet on one of the computers *linked* to the Internet. The Internet itself does not contain any information. Rather, it is the World Wide Web (WWW or the Web, as it is popularly known today) that incorporates all of the Internet services mentioned above, and much more. The Web helps retrieve documents, view images, animation and video, listen to sound files, speak and hear voice, and view programmes that run on practically any software in the world provided our computer has the hardware and software to do these things.

How did it all begin? Let us first briefly consider the development of the Internet that paved the way for the Web. It was in 1960s that Pentagon, headquarters of the United States Department of Defence, embarked upon an ambitious project through its agency ARPA (Advanced Research Project Agency) to develop a network of computers in which one computer could communicate with another. The nodes of the network were to be highspeed computers which were in real need of good networking for the national research projects and other development programmes. By December 1969, an infant network came into being with just four nodes, called ARPANET. The four computers could transfer data on dedicated high-speed transmission lines. They could even be programmed remotely from other nodes. Scientists and researchers could share one another's computer facilities over long distance. In 1971, there were 15 nodes in ARPANET, and in 1972 there were 37. TCP or Transmission Control Protocol converted messages into streams of packets at the source, and then reassembled them back into messages at the destination. IP or Internet Protocol handled the addressing; seeing to it that the packets are routed across multiple nodes and even across multiple networks with multiple standards.

ARPANET itself expired in 1989. However, as the 1970s and 1980s advanced, with availability of more powerful computers, it became fairly easy to link the computers to the growing network of networks. Since the software (network protocol) called TCP/ IP was public domain, and the basic technology was decentralised, it was difficult to stop people from barging in, linking up somewhere or the other. This is what came to be known as the "Internet". The nodes in the growing network of networks were divided up into basic varieties, say, gov, mil, edu, com, org and net. Such abbreviations are a standard feature of the TCP/IP protocols. The use of TCP/IP standards is now global.

What was the situation prior to 1989? The Internet only provided screens full of text, usually only in one font and font size. Surely, it was good for exchanging information, and even for accessing information such as the library catalogues. But, it was visually very boring. Graphical User Interfaces (GUI) added a bit of colour and layout giving it a slightly better look. In the mid-eighties, personal computers were just beginning to adopt Windows interfaces. One of the significant predecessors of the Web was the *Xanadu* project, which worked on the concept of *hypertext*, or the machine-readable text that is organised so that related items of information are connected. Clicking on a *hyperlink* (a word from a hypertext file) would link the user to another location or file. It is interesting to note that it was to click on the hyperlinks that the mouse was invented by Douglas Engelbart. The mouse was to later become a very important part of personal computers. The idea of clicking on a word or a picture to take a user somewhere else was a basic foundation of the Web.

Next came URL (Uniform Resource Locator), allowing one to find one's way around by naming a site. Yet another feature was the *Hypertext Markup Language* (html), the language that allowed pages to display different fonts and sizes, pictures, colours and so on. Before HTML, there was no such standard. The GUIs we talked about earlier only belonged to different computers or different computer software. They could not be networked. This was the situation that existed till 1989, when Tim Berners Lee brought this all together and created the World Wide Web (WWW or the Web). It may not be an exaggeration to say that the Web saved the Internet! Not only did it change appearance of the Internet, it made it possible for pictures and sound to be displayed and exchanged. How did it all happen?

The Web was, in fact, invented to deal with a specific problem. In the late 1980s, CERN was planning one of the most ambitious scientific projects ever, the Large Hadron Collider, or LHC. We may note that LHC was started, and then shut down again because of a leak in its cooling system, in September 2008. Tim Berners-Lee's proposal aimed at keeping track of the huge data LHC would generate, sharing it, and linking of electronic documents in laboratories around the world. The first few lines of the proposal read: "Many of the discussions of the future at CERN and the LHC era end with the question - 'Yes, but how will we ever keep track of such a large project?' This proposal provides an answer to such questions". The proposal incorporated three technologies - HTML, HTTP and a web browser client software program to receive and interpret data and display results. An important concept of his proposal included the fact that the client software program's user interface would be consistent across *all* types of computer platforms so that users could access information from many types of computers.

Tim Berners-Lee and his colleagues at CERN, such as Robert Cailliau came up with the first web browser in October 1990, which looked pretty similar to the ones used today. By 1991, browser and web server software was available, and by 1992 a few preliminary sites existed. By the end of 1992, there were about 26 sites. May 1991 was the first time that the information-sharing system using HTML, HTTP, and a client software program (WWW) was fully operational on the multiplatform computer network at the CERN laboratories in Switzerland. All of the documents coded with HTML elements were stored on one main computer at CERN called a "web server" because it "served-up" batches of cross-linked HTML documents. There was only one Web server located at CERN, but by the end of 1992 there were over 50 Web servers in the world, mainly used by thousands of scientists around the world to swap, view and comment on their research, regardless of the distance or computer system.

The Web, as we know, has found uses far beyond linking of electronic documents about particle physics in laboratories around the world. Cailliau still marvels at developments like wikipedia that allow knowledge to be exchanged openly around the Web. A search engine is very centralised, while the Web is totally decentralised. From personal and social networks, industry to commerce, it has transformed the business of doing science itself. This is why the number of WWW (Internet) users that was only a few thousand in 1992 - mostly scientists exchanging information in different parts of the world - swelled to 36 million from all walks of life in 2000. In 2008 it was 1.6 billion. In India, there are 60 million Internet users today as compared to about 4 million in 2003.

How has the Web changed the way we do science? We are familiar with the benefits of journals being published online and links to be made from one paper to another. It has also permitted professional scientists to recruit thousands of amateurs to help them in their research. In one such project, called GalaxyZoo, used this *unpaid* labour to classify 1 million images of galaxies into various types - spiral, elliptical and irregular. This project, intended to help astronomers understand how galaxies evolve, proved to be so successful that a new project now has been launched to classify the brightest quarter of a million of these galaxies in finer detail. There is also an ongoing project to scrutinise and decipher scanned images of handwritten notes about old plant cuttings stored in British museums. This could allow the tracking of changes in the distribution of species in response to, say, climate change. Scientists have thus been utilising the Web to further their research. There are also novel scientific applications of the web allowing social scientists to do things that would have been impossible previously, say in studying the phenomena like social networking.

What does Tim Berners-Lee think of the future of the Web? The next avatar of the Web would be one in which information is given well-defined meaning, better enabling computers and people to work in cooperation. In the near future, these developments will usher in significant new functionality as machines become much better able to process and *understand* the data that they merely display at present. Another key future development is the web-to-mobile initiative, he says. The Web is one of the many different applications which are run over the Internet. However, the achievement of Tim Berners-Lee was to recognise the power and potential of the Internet. Indeed, the Web is now the web of life!

(May 2009)

Longest Celestial Drama of the Century*

On 22 July 2009, we shall have an opportunity to witness one of the grandest spectacles the nature can offer - the total eclipse of the Sun when the Moon would completely cover the disc of the Sun. It is an event so rare that most people do not get an opportunity to witness it even once in their lifetime. On an average, a total solar eclipse may occur at a particular place on the Earth only once in about 360 years. In addition, such eclipses are notorious in having their tracks of totality very narrow and passing over relatively inaccessible regions of the globe. But, the path of totality of the on 22 July 2009 would pass through a large number of cities and densely populated regions. It will also be the *longest* total solar eclipse of the century, with totality lasting for 6 minutes and 39 seconds at maximum along its path, making it the longest until 2132. Under the most favourable conditions, however, the totality can last for a maximum of 7½ minutes.

How do the eclipses of the Sun take place, anyway? An eclipse of the Sun takes place when the Moon comes between the Earth and the Sun so that the Moon's shadow sweeps over the face of the Earth. This can occur on new Moon day (though not on *every* new Moon day due to the inclination of the Moons orbit). This shadow consists of two parts: the umbra, or the total shadow, a cone into which no direct sunlight penetrates; and the penumbra, or partial shadow, which is caused by light reaching from only a part of the

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* India witnessed the longest Total Solar Eclipse of the 21st century on 22 July 2009. The editorial talks about the grand phenomenon.

Sun's disc. To an observer within the umbra, the Sun's disc appears completely covered by the disc of the Moon. Such an eclipse is called the *total* solar eclipse. To an observer within the penumbra, however, the Moon's disc appears projected against the Sun's disc so as to cover it partly. The eclipse is then *partial* to the observer. The umbral cone being narrow at the distance of the Earth, the total solar eclipse is observed only over a narrow strip of land or sea over which it passes. The partial solar eclipse, however, can be seen from a large number of places covered by the penumbra.

By a remarkable coincidence, the sizes and the distances of the Sun and the Moon are such that they appear very nearly the same angular size from the Earth. However, their apparent sizes depend on their distances from the Earth. This happens because the Earth revolves in an elliptical orbit around the Sun and the Moon too revolves in an elliptical orbit around the Earth. When the Sun is closest to the Earth, and Moon the farthest, the apparent disc of the Moon is smaller than that of the Sun. The Moon passing over the Sun's disc cannot cover it completely, but leave the rim of the Sun visible. Such an eclipse is called *annular*. In India, we shall have an opportunity witness annular eclipse of the Sun on 15 January 2010 that would be visible in southern parts of the country. Sometimes the Earth misses the umbra but only intercepts the penumbra. Under such circumstances, only *partial* solar eclipse is observed anywhere on the Earth. Moon's disc then does not pass across the centre of the Sun. Incidentally, partial eclipses of the Sun are more frequent than total or annular eclipses.

Why is a total solar eclipse so grand a spectacle? An hour before the totality, there is almost no change in the conditions where a person may be stationed. About twenty minutes before totality, there is a sizeable decrease in the intensity of light. Some three minutes before, the sky darkens considerably. Only a narrow crescent of the Sun can be seen. If you are on a hilltop, and if the eclipse takes place in the afternoon, you may see the umbral shadow of the Moon approaching from the western horizon at a speed of about 800 metres per second (or about 2.5 times the speed of sound). About one minute before the totality, ripples of dark and bright bands, called 'shadow bands', appear to move over a white plain surface. The intensity of light quickly drops in the next few seconds, and this is when the real drama begins. The sunlight shining through the valleys of the Moon, called the Baily's beads, give the appearance of a beaded necklace. And the final flash of light from the Moon's valleys produces a brilliant flare known as the 'diamond ring. Soon after the diamond ring vanishes, the chromosphere or lower atmosphere of the Sun that lies just above the visible photosphere blazes into view, indicating that the totality has just begun. One can then see red or orange jets of fire shooting to millions of kilometres above the surface of the Sun, called prominences. The Sun is now completely hidden behind the Moon and the magnificent pearly white corona flashes into view. Corona is the Sun's outer atmosphere consisting of hot sparse gases that extends to millions of kilometers. It is generally quite feeble, its brightness being comparable to that of the Moon and hence not visible ordinarily due to the glare of the photosphere. The shape of the corona varies with the 11-year solar cycle giving it a different look during every total solar eclipse (depending on whether the number of sunspots is maximum or minimum). And, before you realise what has happened the entire sequence repeats in the reverse order!

Strange things happen in nature in these few moments of totality and few minutes before and after totality! The sunlight is greatly reduced and planets and bright stars become visible to the naked eye. Many plants that close up during night close up during the phase of totality. Plants that give agreeable fragrance during night do so during the totality. Birds get confused. The owls and the bats come out. Fowls sit down where they are, and the cock may crow after totality! Pigeons may go to roost before totality and may come out again after totality is over! Surely, one needs to live through the experience of the total eclipse of the Sun. There is no way it could be explained. It is worth travelling any distance to observe a total solar eclipse.

Why do the scientists eagerly wait for this event? The Sun is the nearest star we can study in minute details, and a total solar eclipse gives us the opportunity to study the atmosphere of the Sun-like stars. Further, the corona can be studied in minute details only during such rare events. Indeed, the element helium was discovered on the surface of the Sun during an expedition on 17 August 1868 in the tobacco fields of Guntur, Andhra Pradesh, by the French astronomer Janssen. This is where the solar physics was born - in the tobacco fields of Guntur! Helium was discovered on Earth only in 1895! It was during the total solar eclipse of 29 May 1919 that the General Theory of Relativity of Einstein was first tested by observing the deflection of light coming from a distant star by the gravitational field of the Sun.

On 22 July 2009, when an exceptionally long total eclipse of the Sun takes place, the path of the Moon's umbral shadow would begin in the Gulf of Khambhat (Cambay), India, and cross through Nepal, Bangladesh, Bhutan, Burma, and China. The umbra of the Moon's shadow will first touch the Earth off the western coast of India at sunrise at 6.23 a.m. at a speed of about 18 kilometres per second. Within seconds, the coastal city of Surat (Gujarat) will experience darkness for 3 minutes and 17 seconds. The Sun would be only 3° above the eastern horizon. The altitude of the Sun, however, would rapidly increase as the umbra rushes eastward. Vadodara in Gujarat will be on the northern limit of totality and will experience darkness for one minute and 19 seconds.

The shadow will then reach Indore, which will experience totality for 3 minutes and 13 seconds. The altitude of the Sun here is merely 6° above the horizon. Although Bhopal lies 40 km north of the central line, it would experience totality for 3 minutes and 12 seconds. Varanasi and Patna both lie within the shadow's path. The track of the umbral shadow will then sweep over Darjeeling, Shiliguri, Gangtok, Thimphu (Bhutan), Dibrugarh and Itanagar. It would take only about13 minutes for the umbral shadow to cross India. The shadow then enters northern Myanmar and then China and Japan. After leaving mainland Asia, the path crosses Japan's Ryukyu Islands and curves southeast through the Pacific Ocean where the maximum duration of totality reaches 6 minutes 39 seconds. Here the speed of the umbral shadow would be only about 800 metres per second.

How could one safely watch a solar eclipse? First thing to remember is to never watch the Sun - eclipsed or uneclipsed - with naked eye. It could permanently damage the retina and the vision. For direct viewing of the partial phase of the eclipse, use only tested safe solar filters, or the dark arc welder's glass No. 14. Vigyan Prasar provides safe solar filters in its astronomy activity kits, or even separately for this purpose. Sun's image could be projected onto a wall or a white paper using a small telescope to observe the progress of the eclipse. Safest way of course would be to project the image of the Sun on a shaded wall through a pinhole. The intensity of the uneclipsed portion of the Sun, even when it becomes a thin crescent, remains high enough to cause permanent or partial blindness. Surely, during the phase of totality, one does not require any filters. Preferably, an experienced person should accompany eclipse watchers to announce the beginning and the end of the totality.

What are the prospects of watching the oncoming eclipse from India? It would commence early morning with sunrise when the Sun's altitude would be very low. Next, the event takes place at the height of the south-west monsoon! But, for many of us, this would be the only opportunity in our lifetime to watch this awesome celestial drama. The satellite observations of cloudiness compiled by NASA, however, show a minimum in the central line cloud cover just east of Patna. This may be the best region in the country to watch the eclipse. After 1898, India witnessed total solar eclipses on 20 February 1980, 24 October 1995, and 11 August 1999.

I witnessed the events of 1980 and 1995. In 1999, we organised an expedition to Kachchh, Gujarat, where weather prospects were expected to be good. Alas! We only had to talk about the clouds and the rains. But, many in southern parts of Gujarat could observe the entire sequence where weather prospects were not at all good! The next solar eclipse with track of totality passing over thickly populated areas of India would take place only in 2114, that is, over a century later. Let us not miss one of the grandest spectacles nature offers.

(June 2009)

Angels, Demons and Science Communicators

Just before the Large Hadron Collider (LHC) at European Organisation for Nuclear Research (CERN) was switched on, television channels were abuzz with reports that it would produce black holes that would destroy the Earth. During popular science talks, often there were questions with serious concerns over the possible fate of our planet as a result. LHC was switched on 10 September 2008 for the first time - and of course, nothing happened! Many heaved a sigh of relief! Incidentally, LHC would be the largest and the most complex particle accelerator in the world. On 19 September 2008, the operations were halted due to a serious fault. Due to the time required to repair the resulting damage and to add additional safety features, the LHC is now scheduled to be operational again in September 2009. But, now there is yet another perceived danger from LHC, the seed of which can be found in a recently released blockbuster *Angels and Demons*. And the danger? Antimatter - the supposedly deadly ingredient of a weapon of unsurpassed destructive power that LHC may produce!

Angels and Demons is a bestselling mystery-thriller novel written by American author Dan Brown. It revolves around the quest of a fictional Harvard University symbologist to uncover the mysteries of a secret society and to unravel a plot to annihilate Vatican City using antimatter stolen from LHC. I recently saw the brilliant film adaptation of the novel, released with the same title in May 2009. Though the novel is a work of fiction, and the way antimatter is put to use in the novel is also fiction, antimatter itself certainly is not.

Angels and Demons does provide ample thrill, but it also spreads unscientific notions.

We see signature of antimatter in cosmic rays which are high energy charged particles that strike the Earth from outer space and produce cascades of showers of secondary rays and particles when they collide with the atmospheric particles. Antimatter is routinely made in high-energy collisions inside particle smashers the world over. In hospitals, radioactive molecules that emit antimatter particles are used for imaging in the technique known as positron emission tomography. What is antimatter anyway? And how to reduce the impact of unscientific notions such works of fiction spread?

It turns out that every particle has an antiparticle with the same mass but the opposite electric charge. Thus, the proton has the negatively charged antiproton, and the electron has the positively charged anti-electron, also called positron. Even neutral particles can have antiparticles. The neutron has no charge. How can it have an antiparticle, then? Quarks - the smaller particles that it is made of - have charge. Turn these quarks into 'antiquarks' by flipping their charges, and you have an antineutron! It is these antiparticles that make up the antimatter.

The first hint of the existence of antimatter came in 1928 as a consequence of the work of the British theoretical physicist P. A. M. Dirac. He had been doing research into the equations that govern the motion of elecrons in electric and magnetic fields. At slow speeds the physics was well understood, but the development of theory of relativity in 1905 suggested that the description was bound to go wrong if the electrons were moving at speeds close to the speed of light. When Dirac came to solve his equation, he discovered that it produced two solutions. One solution described the electron perfectly, the other a particle with the same mass but opposite electric charge. However, no such particle was known at that time. The problem was resolved when Carl David Anderson discovered the positron in 1933 in cosmic rays. This particle was the second solution to Dirac's equation.

Notoriously, matter and antimatter destroy each other, or annihilate, whenever both come into contact. No doubt, Dan Brown is correct here! An electron and a positron mutually destruct in a puff of light consisting of two photons sent out in precisely opposite directions, each with an energy corresponding exactly to the mass of the electron (and positron). According to the theory, matter and antimatter were created in equal amounts at the big bang, the moment the universe came into being. If so, both should have annihilated each other totally in the first second or so, and the cosmos should be full of light and nothing else! But we are here, and so are planets, stars and galaxies!

So, where is all the antimatter, anyway? It is likely that there might be some subtle difference in the physics of matter and antimatter that left the early universe with a surplus of matter. Alternatively, the annihilation was not total in those first few seconds of the creation of the universe. Somehow, matter and antimatter managed to escape each other's fatal grasp. Who knows, somewhere out there, in some mirror region of the cosmos, antimatter is lurking and has coalesced into anti-stars, anti-galaxies and maybe even anti-life! If an anti-galaxy were to collide with a regular galaxy, the resulting annihilation would be of unimaginably huge proportions. But, we are yet to see any such signs. However, it is also true there are many regions of the universe that are too far away for us ever to see.

Let us now consider how we can "produce" antimatter. How do we produce and hold a substance that simply vanishes the moment it comes into contact with anything? Even to produce anti-hydrogen with one antiproton and one anti-electron (positron), the simplest anti-atom, one requires a near perfect vacuum. Encounter with a mere single atom of air would destroy any antiparticle. And how do we trap the antiparticles? Certainly not through conventional means! We would need to use electric and magnetic fields for the purpose. We may note that anti-hydrogen was isolated in 2002 at CERN by bringing together antiprotons from a particle accelerator and positrons from a sodium radio active source in a magnetic trap. But, let us remember anti-hydrogen *is* neutral, and hence such success is only momentary. Magnetic traps may work for charged particles, not for neutral atoms. Hence, it can slip right through the magnetic field! Then, how did they transport antimatter in the small canister containing antimatter in *Angels and Demons*?

True, at the moment we have enough difficulty even to produce and tame anti-hydrogen. But, can we ever expect to make anti-helium, anti-carbon, and all the anti-elements, thereby producing an anti-periodic table? Shall we be able to produce organic anti-molecules made from anti-carbon? The problem is to build one sub-atomic anti-particle at a time and then assemble several of them successively to build anti-atoms of heavier anti-elements! So, what are our chances of making anything more complex than anti-hydrogen? Almost zero, indeed, though not quite zero!

And what about the antimatter bomb which is the central part of *Angels and Demons* plot? How much energy would be released in the annihilation of 1 gram of antimatter with 1 gram of matter (which makes 2 grams)? Using Einstein's formula E=mc2, it is easy to find that 2 grams of matter-antimatter annihilation corresponds to energy equivalent of 42.8 kilotonnes of TNT (trinitrotoluene, a high explosive).

Now, twenty kilotonnes of TNT is the equivalent of the atom bomb that destroyed Hiroshima. This implies that one 'only' needs half a gram of antimatter to be equally destructive as the Hiroshima bomb, since the other half gram of (normal) matter is easy enough to find. At CERN about 107 antiprotons are produced per second and there are 6x1023 of them in a single gram of antihydrogen. At this rate, it would take roughly two billion years to produce half gram of anti-hydrogen! And 1 billion years to produce 1/4 gram of antimatter stolen from LHC in *Angels and Demons!* Now, ¼ gram of antimatter would produce energy equivalent to 10 kilotonnes of TNT, but what was cited in the movie was 5 kilotonnes. Apparently the energy from the normal matter was not taken into account!

Antimatter is made by accelerating particles and smashing them into each other, a process which requires a very large amount of energy. For this reason, antimatter poses no realistic threat as a tool of destruction, since it requires much more energy to create than is released upon annihilation. This is why it cannot be used as an energy source. In addition, antimatter is not portable in real life, although in the movie, scientists transport it in a canister.

We may note that antimatter has many useful applications too, other than destroying cities. For instance, in PET (positron emission tomography) scans mentioned earlier, a patient is injected with sugar through a vein, and the sugar mixes with a radioactive substance. The sugar goes to areas in the body with high metabolism, showing places of high activity. Meanwhile, the radioactive portion decays and releases a positron (an anti-electron), which very quickly finds an electron in surrounding tissue, and they annihilate into two photons. With many such photons, doctors can create a 3D image of areas inside the body. Antimatter may also help physicists solve some of the biggest mysteries in science, such as the origins of the universe, why particles have mass, and what the universe is made of.

There is likelihood that movies like *Angels and Demons* could spread wrong notions, at times even misinformation, among the people. But they give an excellent opportunity to science communicators to dispel the myths such movies create, and present science in the correct perspective through lectures, talks, discussions, articles, and programmes on radio and television. In particular, *Angels and Demons* is one of the finest examples where angels and demons both come together and offer a wonderful opportunity to science communicators to speak about the true nature of antimatter (and matter); and generate a fresh interest in science among the people.

Meanwhile, I must admit the movie is quite enjoyable! It may be interesting to note that a physicist at CERN who advised on the *Angels and Demons* movie is rumoured to be the inspiration for Leonardo Vetra, an antimatter scientist in the original story!

(July 2009)

Fickle Monsoons, Looming Droughts

The southwest monsoon set in early over Kerala this year, much ahead of schedule (23 May 2009) and got off to a dramatic start. However, cyclone Aila sweeping in from the Bay of Bengal on 25 May 2009 dealt a mighty blow to the progress of the monsoon, wreaking havoc along with significant loss of life in West Bengal and neighbouring Bangladesh. Although the monsoon had reached Kerala much ahead of schedule, cyclone Aila sucked away moisture from the region and weakened the weather system. Thereafter, the monsoon went into a slump and its progress northwards has been tardy.

Though the monsoon picked up over the western flank of the country during the first week of July 2009, large parts of northern India have been left baking in the Sun. The worst affected areas, with rainfall deficiency of 60 per cent or more, include West Uttar Pradesh, Uttarakhand, Haryana, Chandigarh, Delhi, Punjab, Himachal Pradesh and Gujarat. Out of 36 meteorological sub-divisions, rainfall was excess or normal in 11 and deficient or scanty in 25 sub-divisions. We may note that the cumulative seasonal rainfall for the country as a whole was 34 per cent *below* the long-period average (LPA) as on 8 July. India Meteorological Department (IMD) says that widespread rainfall activity would continue uninterrupted in the western region. Further, there were indications that following the recent formation of a low pressure region over the Bay of Bengal, Orissa, Bihar, Jharkhand and the eastern parts of Uttar Pradesh may receive rainfall. However, only scattered rainfall is expected in the north-western region that includes Punjab and

Haryana. We have already started experiencing power blackouts and water scarcity.

In its first long-range forecast issued on 17 April 2009, the IMD had predicted that the nation-wide rainfall during the current southwest monsoon was likely to be 96 per cent of the long-period average. The updated forecast issued on 24 June 2009 reduced the expected monsoon rainfall to 93 per cent. With an error bar of four percentage points (which implies that the total rainfall could even be 89 per cent!), the updated prediction does not preclude the possibility of the monsoon slipping into a drought! Incidentally, the southwest monsoon is said to end in a drought if nationwide rainfall during the four months from June to September falls below 90 per cent of the long period average. Indeed, India was extremely lucky to enjoy good rainfall for thirteen years since 1989 during the south-west monsoon season every year. This had been the third long spell of normal or excess monsoon rainfall years in the past hundred years, the earlier two spells being in 1921-1940 and 1952-1964. But 2002 and 2004 turned out to be drought years!

One could attribute the failure of monsoon to a variety of unfavourable factors that include sea surface temperatures and pressures, correlation between the warm ocean currents off the south American coast and India (El Nino), snow cover, prevailing atmospheric conditions, global warming and so on. Further, the predictions are based on a mathematical model which needs continuous improvement in view of the new data and better understanding of the weather phenomena. Indeed, even after years of effort and experience, we still have not fully understood the strange behaviour of monsoon. Hence, we need to take monsoon predictions with a pinch of salt and not blame the weatherman should the rain-gods fail us. Surely, droughts are nothing new to us. It has been a frequent and a natural phenomenon and follows a cyclical pattern. In last fifty years, we have experienced fourteen major droughts, the one in 1987 being the most severe that affected nearly half the land of our country. Drought or no drought, we need to manage our water resources efficiently, if we do not want the monsoon showers to make or break our fortunes.

But, what if there is a considerable shortfall in July? Indeed, rainfall in July across the country is crucial for agriculture. Of late, scientists have noticed a marked decline in precipitation in the month of July, which is a deviation from the regular rainfall pattern. Incidentally, July shortfalls played a big part in producing the droughts of 2002 and 2004. In addition, the El Nino, or the unusual warming of the equatorial waters of the central Pacific is a cause for concern. El Nino is often associated with poor monsoons over India, though not always.

So far, the rainfall has been too late and too little in many parts of the country despite the monsoon season being half-way through; especially in the northwestern region that supplies most of the wheat and rice for the public distribution system. Surely, the worst impact has been on agriculture. Kharif crop is on the verge of being ruined in most of the affected States. Even if rains come now, the yield will be considerably reduced since crop duration and yield are related. It is important to note that in the case of monsoon rains, it is not only total rainfall that is significant, but the distribution of the rainfall that determines the health of the crop. The loss occurring from a skewed distribution of rainfall is particularly high in soils with limited waterholding capacity. The only silver lining is the plenty of food grain stocks, which may help us tide over the situation till the next monsoon season.

In the medieval times, individuals and communities played a major role in managing their water resources. Water was blocked by constructing bunds across streams raising the water level and canals were constructed to take water to the fields. These bunds were built by both the state and private sources. However, individuals and communities have steadily given over their role almost completely to the State. Next, the simple technology of using rainwater declined and in its place exploitation of rivers and groundwater through dams and tube wells became the key source of water. Water in rivers and aquifers being only a small portion of the total rainwater availability, there is growing stress on these sources. Today over 80-90 per cent of drinking water and over 50 per cent of irrigation comes from groundwater. This resource is being over exploited – not harvested. There is no gainsaying the fact that without rainwater harvesting no recharge takes place. And for sure, rain water harvesting demands a participatory approach.

Over 60 per cent of India's cultivated area is rain-fed. Hence, unless we learn to "manage" a drought, it could become synonymous with the visions of parched earth, cracks in cultivable lands, unemployment, thirst, hunger and death. Indeed, the entire nation could be made drought-free through community rain water harvesting. A success story often cited is that of Dr. Rajendra Singh and his team Tarun Bharat Sangh, who were instrumental in mobilising communities in parts of Rajasthan to rejuvenate their own water resources. The traditional water harvesting structures built by the villagers under his guidance have changed the face of Rajasthan's Alwar and neighbouring districts of Jaipur, Sawai Madhopur and Karoli, making them drought free. River Ruparel started flowing perennially after three decades. Indeed, it is among the five rivers of Alwar that has seen life after death. Yet another famous success story is that of the village Ralegaon Siddhi, Maharashtra, where the efforts on watershed management of Anna Hazare have helped a dry region become green through community participation and existing Government schemes. Why can't we follow the path shown by Rajendra Singh and Anna Hazare in other parts of the country as well?

The immediate task in drought affected areas is to ensure the availability of food and drinking water to both human and animal population. This is so because in many parts of the country, livestock and livelihood are intimately related. An integrated agricultural rescue package consisting of crop life-saving techniques, contingency planning, alternative cropping systems, and compensatory production programmes in areas where there is enough soil moisture could help in reducing the aggregate fall in agricultural production. Regular workshops and training programmes to educate and apprise people on how to harvest rainwater would go a long way in tackling scarcity of water. A campaign to create awareness and provide practical information on rainwater harvesting needs to reach out to cooperative group housing societies and residential colonies, especially in the metros. Such programmes have largely remained a non-starter till now - even after the severe droughts of 2002 and 2004 and the effects of global warming being severely felt. It should now gain momentum. Let us begin right away.

This is the time to initiate socially and ecologically relevant programmes, say, construction of check-dams, digging farm ponds in rural areas where rain water could be stored and utilised for irrigation, deepening of existing ponds and lakes through the already existing schemes like the NREGA. It is imperative to help people understand their own role and responsibility in mitigating drought, and equip them with necessary information, skills and training to keep droughts at bay. It is raining opportunities for the science communicators and voluntary agencies to take up this challenge. This way we would have enough water the year round, and not just when it rains. And even in the case of a fickle monsoon, drought may not loom large and stare at our face!

(August 2009)

Little Water Big Excitement*

The first ever scientific observation of the Moon was made by Galileo 400 years ago when he used his new invention - the telescope - to observe mountains and craters on the lunar surface. The era of space exploration began in 1960s. That is when observations of the Moon received a boost with fly-by, orbiting, landing of space probes, and finally the manned missions and analysis of its rocks for over four decades. Indeed, our fascination with the Moon continues to grow with time. The Moon has now parted with one of its most tantalising secrets giving a boost to the quest for our understanding of the cosmos. India's *Chandrayaan-1* Moon Mission, before dying an early death in August 2009, confirmed that the Moon is not dry after all. There *is* water on the Moon. Moon Mineralogy Mapper (M3), the NASA payload, on board *Chandrayaan-1* spacecraft (launched on 22 October 2008) detected unmistakable signs of water molecules at many places on the surface of our celestial neighbour.

Much before humans had set foot on the Moon, scientists believed that there might be water on the Moon. However, when samples of lunar rock and soil brought back by the Apollo astronauts were analysed, the results were not encouraging. The Moon appeared to be "an exceedingly dry place." However, the possibility of water-ice in the polar regions of the Moon could not be ruled out, since they are

* *Chandrayaan*-1 spacecraft was launched by ISRO on 22 October 2008. After about one year of its launch, *Chandrayaan*-1 detected signals from the moon surface that confirmed presence of water on Moon.

permanently shadowed from sunlight. Due to the very slight tilt (only 1.5°) of the Moon's axis, some of the deep craters, particularly near the polar regions never receive any light from the Sun - they are permanently in shadow and can act as permanent trap of water molecules. In such craters scientists expected to find water in frozen form. It was this hope that revived the search for water on the Moon in the 1990s.

Most of the earlier explorations till mid-1990s appeared to confirm that the Moon was a dry rocky body. As a result of its low gravity (only one-sixth that of the Earth) the Moon has no atmosphere. Any water would have long been lost in space. Or so it was thought. This consensus of a barren, waterless Moon came under increasing doubt, starting with the 1994 *Clementine* mission. In the quest for detecting ice on the Moon, the radio transmitter on board *Clementine* spacecraft (launched in 1994) was used to bounce radio waves off the surface of the Moon to a station listening back on Earth. The energy of the reflected radio waves, incidentally, is a function of the compositional properties of the surface from which they are reflected. Rocky surfaces scatter radio waves randomly, while icy surfaces reflect radio waves coherently. By distinguishing between weak radar return signals and strong radar return signals, it is possible to detect deposits of ice. Radar waves were bounced off of the Moon's north and south poles as well as areas around the poles. The non-dark region displayed the characteristic radar return from a rocky silicate surface. However, the permanently dark regions at the South Pole had the radar reflectance properties of water ice. Radar data collected from the lunar North Pole and other regions without permanent darkness did not have the ice signature.

The *Lunar Prospector* (launched in 1998) was designed for a low polar orbit investigation of the Moon, including mapping of surface composition and possible polar water ice deposits. The technique used for finding the evidence of water was neutron spectroscopy in which a neutron spectrometer on board the spacecraft determines the number of neutrons that interact with wet lunar soil as compared to the dry lunar soil. Neutrons, incidentally, are the neutral constituent particles of the nuclei of elements along with positively charged protons. Lunar soil containing water significantly slows down the fast moving neutrons due to collisions with the hydrogen ions in the water molecules. This technique thus gives the definitive signature of the presence of water. On 31 July 1999 the *Lunar Prospector* impacted the Moon into a crater near the South Pole in a controlled crash to look for evidence of water ice. No conclusive evidence of water ice, however, was found. We may note that water molecules and hydroxyl (OH) radicals were suspected in data from *Cassini* spacecraft flyby of the Moon in 1999, but the findings were not published until now.

In 2008, Japanese researchers declared that careful analysis of images taken by the *Kaguya (Selene)* spacecraft did not throw up any sign of water ice inside a key crater at the South Pole. In the same year, U.S. scientists published a study that used new techniques to examine beads of volcanic glass collected by two Apollo Missions. They found minute traces of water! It suggested that water had perhaps been a part of the Moon since its formation and could be found deep inside it. Against this background, the discovery of traces of water by the *Chandrayaan-1* is of huge scientific interest. *Chandrayaan's* observations are also supported by findings from two U.S. deep space missions that gazed at the Moon as they passed by – *Deep Impact* spacecraft (launched in 2005) and *Cassini* (launched in 1997).

The Moon Mineralogy Mapper (M3) on board *Chandrayaan-1* detected light reflected off the Moon's surface in the infrared part of the electromagnetic spectrum that indicated the chemical bond between hydrogen and oxygen - the telltale sign of either water (H_2O) or hydroxyl (OH). Because M3 could only penetrate the top few millimetres of lunar soil, the newly observed water seems to be at or near the lunar surface. M3's observations also showed that the water signal got stronger toward the polar regions. *Cassini*, which passed by the Moon in 1999 on its way to Saturn provided confirmation of this signal with its own slightly stronger detection of the water/ hydroxyl signal. The *Cassini* data showed a global distribution of the water signal, though it also appeared stronger near the poles (and low in the lunar maria, that is, "lunar seas"). Finally, the *Deep Impact* spacecraft, as part of its extended *EPOXI* mission and at the request of the M3 team, made infrared detections of water and hydroxyl as part of a calibration exercise during several close approaches of the Earth- Moon system *en route* to its planned flyby of comet 103P/Hartley 2 in November 2010. *Deep Impact* detected the signal at all latitudes above the 10° North latitude. Again, the poles showed the strongest signals. With its multiple passes, *Deep Impact* was able to observe the same regions at different times of the lunar day. At noon, when the Sun's rays were strongest, the water feature was lowest, while in the morning, the feature was stronger.

These observations of the Moon not only unequivocally confirmed the presence of water/hydroxyl on the lunar surface, but also revealed that the entire lunar surface is hydrated during at least some portion of the lunar day. Data from *Chandrayaan* show that although the water is present mostly at the poles, it is also thinly spread over the surface up to about 10° south and north of Moon's equator. It appears that the water evaporates as the Sun heats up the surface in the Moon's daytime and condenses back in the night. In some of the polar craters, where sunlight has not reached for the past 3-4 billion years, the water could exist as ice, since the temperatures are about 240° Celsius *below* the freezing point of water (or 33° Kelvin) – the coldest region in the entire solar system as observed by NASA's *Lunar Reconnaissance Orbiter* (LRO) in September 2009 (launched in 2008).

Now that we know that the Moon is not entirely dry, the question that arises is - how did the water get there? There are two possibilities. First, the water was brought from outside sources, such as meteorites and comets striking the surface of the Moon. True, bulk of the water may have been lost, but some still may have remained. The second possibility is that the water originated on the Moon itself. This second "endogenic" source is thought to be the result of the interaction of the solar wind with Moon rocks and soils. The solar wind - the constant stream of charged particles emitted by the Sun - consists mostly of protons, or positively charged hydrogen atoms travelling at onethird the speed of light. The rocks and lunar soil that make up the lunar surface are about 45 percent oxygen combined with other elements - mostly silicate minerals. When the protons in the solar wind hit the lunar surface with enough force, they break apart oxygen bonds in soil materials. Where free oxygen and hydrogen exist there is a high chance that trace amounts of water will form. Further, various studies also suggest that the daily cycle of dehydration and rehydration of the lunar surface by this trace water could lead to the migration of hydroxyl and hydrogen towards the poles where it can accumulate in the cold traps of the permanently shadowed regions. The temperature of 33° Kelvin is cold enough to trap stray water molecules over the eons from the impact of comets or asteroids on the Moon or water that is produced on the Moon itself due to the interaction with the solar wind.

Water, it would seem, is being constantly generated all over the lunar surface. Much of it may well boil off into space and some of it may percolate deeper down into the soil; but some of the water would certainly end up at the bottom of the shadowed and deep polar craters. Perhaps the most valuable result of these new observations is that they prompt a critical re-examination of the notion that the Moon is dry. It is not.

The new findings based on the observations of *Chandrayaan-1*, *Cassini*, and *Deep Impact* spacecraft were published in the 25 September 2009 issue of the journal *Science*, and came in the wake of further evidence of lunar polar water ice by NASA's *Lunar Reconnaissance Orbiter*. Just two weeks later, on 9 October 2009, NASA's *LCROSS* satellite crashed on one of the permanently shadowed craters at the Moon's South Pole in a controlled manner in the hope of churning up evidence of water ice deposits in the debris thrown up. However, no spray of dust and debris could be seen. The scientists are looking for spectroscopic changes detected around the impact site. Determining whether it was water may take weeks or months of data analysis. The Moon, however, remains drier than any desert on Earth, and the water is said to exist on the Moon in very small quantities. One tonne of the top layer of the lunar surface would hold only about one litre of water.

Water exists on many bodies in our solar system - on planets and also on their numerous satellites. But finding it on our own Moon is certainly awe-inspiring. First, it adds to our knowledge of how cosmic processes work. And next, it could open the way to utilising the water on Moon for making hydrogen and oxygen for meeting requirements of fuel and sustaining life. It could even pave the way towards using the Moon as a base camp for space exploration in the years to come. Could it happen in practice? Let us remember that the discovery of a molecular layer of moisture on the lunar surface is still a long, long way from any practical utilisation.

It is the search for survival options that prompts humankind to strive for more sophisticated technology, effective medicine, and exploration of space for water and earthlike planets. It is imperative that we remind ourselves that the mysteries of the cosmos are far more profound than fulfilment of human needs. It is not even clear when humans might next go to the Moon, let alone set up bases there. Missions of space exploration cannot (and should not) be judged by any immediate returns they may produce. The excitement over such voyages alone is what could propel us towards better understanding of the world around us and the universe beyond.

(November 2009)