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First Indian at the South Pole*

Sledge Odyssey to Antarctica

PARMJIT SINGH SEHRA
Professor of Meteorology Agronomy
Department of Agricultural Meteorology
Punjab Agricultural University
Ludhiana 141 004

ADAPTABILITY certificate: Thinking that the Russian doctor on board the ship 'Viese' sailing to Antarctica might be asking for my International Health Certificate, I promptly gave him that. But he smiled and remarked, "Wintering over the South Polar Ice-cap where the temperatures range from -40 to -90°C and the winds blow with speeds exceeding 200-300 km per hour is not a joke, my friend. Your certificate is meant only for the posh cities of the world. Antarctica demands from an individual the utmost in physical stamina and mental soundness with mature judgement so that a man working there may act quickly and positively in order to survive. Prior to selection for Antarctica, we conduct a thorough medical check-up and a tough physiological and psychological screening of our expedition members and also impart them a special training. Only after qualifying all these tests and training they are given 'adaptability certificate' and taken to harshest continent Antarctica".

Fig. 1: Icebergs floating in the frozen Antarctic Ocean

I did not undergo any special acclimatisation programme or training before setting foot at the South Pole. I had no 'adaptability certificate' and the Soviets (erstwhile USSR) allowed me to participate in their Antarctic Expedition during 1971-73 at my own personal risk. My long Antarctic ordeal included many unforgettable scary moments in the ice.

What is Antarctica? In Greek it means "Anti-Arctic i.e. the opposite of the Arctic". Including its permanently attached ice shelves, Antarctica covers about 5.5 million square miles ($14.23\times10^6 km^2$ approximately) surrounding the South Pole, and has 18,500 miles (29,767km) of coastline. It is as big as the United States and Mexico combined. About 95 per cent of the world's permanent ice is in the Antarctic: 7 million cubic miles ($30.5\times10^6 km^3$) of it. This great mass has made Antarctica the highest of all continents, its average elevation is about 4,500 feet (225m). The world's lowest

*Reproduced with permission from "Indian Mountaineer", Vol. 2, 1978

temperature minus 88.3°C has been recorded in Antarctica and violent snowstorms with winds of over 250 km per hour speed are very frequent in this icy desert. It is the coldest and the windiest continent.

Fig. 2: Map of Antarctica and South Pole

Although there is so much ice in Antarctica, there is almost no fresh water. Such a cold dry area cannot support much life of any kind. On land only 4.5 per cent of which is bare, a few primitive plants exist, and there are bacteria and some insects and similar small animals. The Antarctic waters, however, abound in sea life ranging from microscopic plants, plankton to giant whales. The best-known birds in Antarctica are the flightless penguins, which walk erect and waddle along like a cartoonist's version of man returning from a formal dinner! Wandering through the ice pack, penguins frequently encounter seals, six species of which breed in the Antarctic. There are also colonies of some flying birds such as the polar skuas and snow petrels. To the present knowledge, Antarctica has never had any native human population. Men now go to Antarctica primarily to study the earth, the space around it and the life upon it.

The climax of our Antarctic Expedition came in when we reached the geographic South Pole. I got lost in my deep thoughts while standing at the bottom of the world (90 degrees South) on a high ice-covered plateau more than 9,000 feet (nearly 2,700m) above sea level. The temperature at that time was 60°C and the pressure much below the normal. It was the place first reached by the great Norwegian explorer Roald Amundsen 60 years ago (1911). On January 17, 1912 about a month after Amundsen, Captain Scott and four other Englishmen stood on the same spot, who were later trapped by a blizzard and never returned home.

At this historical place there is an American station called Amundsen-Scott South Pole Station, which has been in operation since 1957, the International Geophysical Year. The sun sets here for the winter on March 22, not to rise again until September 21. A full year consists of only one day and one night, each of six months duration. On June 21, the

sun begins its ascent marking Midwinter Day. As at all stations this turning point of the winter was celebrated with gusto. With the day marked by holiday routine, practically every one of us slept late. The only exception was our cook, who was busy preparing a lavish meal for that evening.

Fig. 3: Glaciological and Geodetic observations being made on way to Vostok. The author participated in the 1,500 Km sledge odyssey from Mirny to Vostok, the pole of cold, completed in one and a half months

Now a desperate struggle of two months to reach 'Vostok', the pole of inaccessibility and extreme cold (having recorded the world's lowest temperature (minus 88.3°C). During our 1,500 km trekking from Mirny station to Vostok located at the geomagnetic South Pole, we had plenty of difficulties, we sometimes failed, we sometimes won, we always faced them and made all possible scientific observations.

Our trekking expedition comprising of heavy machines 'towmobiles' and dog sledges carrying about 30 tons of equipment for Vostok roared into action and slowly pulled out of Mirny during the summer. After two weeks, a heavy snowstorm began reducing the visibility to zero. Most of the route was 3,000 metres above sea level with constantly low temperatures, about minus 70°C due to which our snow tractors could not move. Many of our huskies pulling our sledges died on the way and we had to eat their meat in order to survive. Snowstorms and poor visibility continued to hinder our progress. One of our comrades who became ill with acute appendicitis died on the way and yet another fell into a deep crevasse and buried alive. Despite all these difficulties, we traversed 1,500 kilometres in two months, and conquered the pole of inaccessibility. I can forget anything in my life but not these tough experiences. I must add here that one who has not travelled deep into the South Pole Ice-Cap cannot know Antarctica!

The coldest place in the world 'Vostok' at 78.45 degrees South and 106.8 degrees East lies at an altitude of 3,488* metres on approximately 3,700 metres of ice. The air is perpetually drier then in the world's worst deserts. During the polar night, temperatures drop so low that they would normally freeze carbon dioxide out of the atmosphere which freezes at -78.5°C. The high altitude starves lungs of oxygen, and the normal rate of heartbeats nearly doubles. Here 15 of us wintered over, isolated from contact with rest of the world for more than nine months, half of this time in utter darkness. I must say that six months continuous darkness followed by six months daylight at the South Pole were the extremely boring phenomena of nature I experienced there. When I returned, I found that a 12 hour day

Fig. 4: A view of the Soviet Antarctic station 'Molodezhnaya'. During the extremely cold, dark and stormy 6-month long night, some of the huts were blown off along with the inmates. Winters are harsh and there is plenty of snow accumulation due to violent snow-storms. Some huts are built underground wherein sound does not reach, nor does light filter through.

followed by a 12 hour night were, indeed a great blessing!

During our 1500 km sledge odyssey between Mirny and Vostak, we made snow measuring observations and set up new automatic stations for the continuous recording of magnetic variations and meteorological data in addition to our other field work on geodesy, glaciology and so on.

Circumnavigating all around the Antarctic continent on board the icebreaker ships 'Navarin' and 'Ob' during the expedition, was most thrilling voyage of my life which recalls me of Captain James Cook who between 1772 to 1775 first sailed around Antarctic and brought to an end the dream of an inhabited southern continent.

During the Antarctic circumnavigation our ships resupplied all the Soviet coastal stations viz. Mirny, Leningradskaya, Bellingshausen, Novolazarevskaya, Amery and Molodezhnaya and relieved the old staff with the new expedition members. We sailed all along the Antarctic Circle and chose the site of a new Soviet station 'Russkaya' on the shore of the Amundsen sea. We took fuel and fresh food provisions for our ships and for the Antarctic stations from the port of Punta Arenas, Chile. But, unfortunately, the station Molodezhnaya could not be given sufficient food supply due to which we had to face a number of problems there. I visited several other stations operated by the Antarctic Treaty member-nations in order to collect maximum possible scientific data.

Fig. 5: 'M-100' rocket at take-off from the launching-pad near 'Molodezhnaya' Antarctic station during the extremely cold, dark and stormy 6-month long South Polar night

Fig. 6: About 95 per cent of the world's permanent ice is in the Antarctic-7 million cubic miles (1 cubic mile is nearly 4.1 cubic kilometre) of ice. Large pieces of ice called icebergs break off from the ice-shelves and ice glaciers and float away from the coast. The author and comrade Merculov resting in the Ice of an ice-berg.

I worked for more than a year at the station 'Molodezhnaya' which is the continental headquarters for the Soviet Antarctic Expeditions. During the harsh winter, an emergency was declared at our station due to the acute shortage of food stuff and other essential provisions. Both the quality and quantity of food were utterly poor. Our tinned food also got exhausted during the extremely cold and stormy polar night. As a consequence, we had to live on the Antarctic seals, penguins and fish. I still remember my days in Antarctica when we also had to eat the meat of our favourite huskies in order to survive. Smokers at the station were often found searching for the used cigarette butts. When the 'Vodka' was also finished, many of us started drinking pure spirit mixed with tea-water, Antarctic whisky!

Besides this, we faced innumerable number of other difficulties while wintering in Antarctica. Comrade Evanov developed appendicitis trouble and had to be operated. Two of our expedition members became mentally ill due to long isolation and had to be closed indoors. During the winter, we encountered several violent blizzards with speeds exceeding 200 km per hour. Some of our houses were blown off along with the inmates and our unfortunate comrades died for the cause of science.

Fig. 7: A heavy 'towmobile' machine, a sort of snow-tank which is the latest mode of transportation in Antarctica

Rebirth! yes, in a way I was reborn when I fell into a deep crevasse in Antarctica on 14th March 1972. I was hardly an inch away from my death when I was pulled out of the 'death pit' with long ropes by a timely rescue party. In another accident I fell down from a 200 metre ridge due to a helpless blind-walk in a violent snowstorm and lost few teeth and suffered a fracture in my legs. In November 1972, I undertook an independent trekking to a distant iceberg which was about 150 km far and named it as 'Indian Elephant Ice-berg'. On the

Fig. 8: The seas surrounding the Antarctic continent freeze during winter months for hundred of miles offshore. In summer the ice breaks up to form pack-ice which constitutes a hazard to shipping and a barrier, making access to the coast extremely difficult. For these reasons special ice-breaker ships are used

return from there, misfortune followed my footsteps. Growing weaker each day from the exertion and the lack of food, I also encountered violent storms and blizzards and lost the way. I met with several hair-raising accidents during my South Pole odyssey, but fortune ever smiled on me and I always had a narrow escape.

In Antarctica, I was the Project Scientist for carrying out the upper atmospheric rocket soundings from the main Soviet Station Molodezhnaya. The M-100 rockets could carry 67 kg payload upto 100 km altitude and were launched twice in a week. My research and investigations showed for the first time that sizable perturbations occur in the South Polar atmospheric structure during the winter.

My participation in the Soviet Antarctic Expedition in 1971-73 was made possible (through the efforts of Prof. P.D. Bhavsar, Prof. P.R. Pisharoty and the late Prof. Vikram A. Sarabhai) under an agreement between the Indian Space Research Organisation and the Hydrometeorological Service of the USSR.

Fig. 9: The author in the company of penguins. The penguins are very curious and social birds and frequently come close to camps, ships and groups of men to watch what is going on. They usually walk erect and waddle along looking like a cartoonist's version of man returning from a formal dinner

Editor's Note

India is amongst few countries of the world that has been actively pursuing programmes to conduct wide ranging studies on Antarctica. It has already established a permanent station on this icy continent. The first Indian expedition to Antarctic Programme was undertaken in 1981. Since then India has been sending multi-disciplinary scientific expeditions to Antarctica every year. In 1983 India commissioned its first research station in Antarctica, which was named as 'Dakshin Gangotri'. It has since been replaced by the indigenously designed second Indian permanent station, 'Maitri' with adequate infrastructure facilities for conducting scientific research of contemporary nature in the icy continent. India has always recognised the importance of preserving the pristine nature of this remote and unique continent. To uphold this commitment, India, an original votary of the Protocol on Environmental Protection to the Antarctic Treaty, has ratified this Protocol in April 1996.

Madame Marie Curie – Radioactivity and Atomic Energy*

N.R. DHAR
Sheila Dhar Institute of Soil Science
University of Allahabad

As late as 1895 physicists and chemists seemed to be convinced that the ultimate particles of matter consist of atoms which cannot be further broken down. In 1896, a new phenomenon, i.e., radioactivity, was discovered by Henri Becquerel (1852-1908) of France, which changed our ideas regarding the ultimate particles of matter. The discovery of X-rays by Prof. Roentgen (1845-1923) in 1895, of cathode rays by J. Plucker (1801-1868) and others also helped in modifying the scientists' notion regarding the atom.

Prof. Becquerel was the Head of the Physics Department of the Natural History Museum in Paris and was an authority on fluorescence of uranium compounds. He exposed a fluorescent potassium uranyl sulphate crystal to sunlight and then placed it on a photographic plate wrapped in black paper and observed an image of the crystal on the photographic plate when it was developed. In the next few days there was no sunlight in Paris and Becquerel put the crystal over a photographic plate wrapped in black paper. In this case also an image of the crystal appeared on the plate. He reported to the French Academy of Sciences in February 1893 (Compt. rend. 122, 420; 24 February, 1896) that this salt, 'must emit radiations which are capable of passing through paper, opaque to ordinary light'. He also observed that the same effect was produced in the dark and by other uranium compounds, and the radiations given out by uranium made a gas conduct X-rays and cathode rays. This was the discovery of the radioactivity of uranium, which is spontaneous decomposition of matter into smaller particles. This subject of radioactivity was greatly advanced by Madame Curie with the help of her husband, Pierre Curie, because they made the capital discovery that a very highly radioactive material, which was named radium, was present in the mineral pitchblende even after the removal of uranium compounds. Radium decomposes spontaneously and much more vigorously with liberation of heat and other radiations than the uranium compounds. This discovery made it possible for man to visualise the production of energy by the breaking of atoms.

Marya (Marie) Curie was the daughter of a Polish Professor Sklodovska and was born at Warsaw on November 7, 1867. As Poland was backward in science at that time, she had to learn science from books; but, in 1890 she could carry on some elementary experiments in physics and chemistry in her cousin's laboratory. She wanted to study science in the Great Centre of

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Learning, Paris, and had to save money for this purpose by serving as a governess for about six years. She joined for a short while her sister and brother-in-law at Paris. Soon afterwards she shifted to cheap lodgings and registered herself for Licence Degree in Science Faculty, University of Paris, Sorbonne, in 1891. She obtained first position in Licence in Physics in 1893 and second position in mathematics in 1894 whilst living in Paris under great privations. In 1893 she carried on some research work on the magnetic properties of steel under Prof. G. Lippmann, a Nobel Laureate in Physics and came in contact with Prof. Pierre Curie of the *Ecole de Physique et de Chimie*, Paris, a great authority on magnetism.

From 1896 she carried on the chemical analysis of numerous uranium minerals found in Prof. Becquerel's Institute and other laboratories in Paris and made a striking observation that the uranium content of these minerals and their power to discharge a charged gold leaf electroscope do not go hand in hand. The power to discharge a gold leaf electroscope, which is caused by the radioactivity of the minerals and the ionisation of the surrounding air, may be large, specially of pitchblende, even after the separation of uranium. By that time, i.e. in 1895, she was married to Prof. Curie who realised the importance of the investigations undertaken by his wife and joined her in these researches. The husband tackled this problem from the physicist's point of view and concentrated on the determination of the properties of the radiations given out. He and others proved that the radiations emitted by radioactive bodies consist of a α-particles, positively charged, consisting of helium, β-rays which are negatively charged and γ-rays, similar to x-rays, are given out. Madame Curie devoted herself to the chemical manipulation of separating large amounts of extraneous substances dealing with one ton of pitchblende supplied by the Austrian Government from which uranium was separated. In April 1898 she came to the conclusion that pitchblende contains an unknown element, much more radioactive than uranium. The problem was to separate the active material from pitchblende by chemical group separation and fractional crystallisation. The radioactivity of the products was determined by the electrometer method. The laborious and the tedious chemical separation was undertaken by Madame Curie. One evening after returning to their laboratory in the *Ecole de Physique et de Chimie*, the Curies were pleasantly surprised to find that their radioactive products were emitting light in the dark room.

Discovery of Radium by Pierre and Madame Curie

In June, 1898 a radioactive element was obtained in bismuth sulphide precipitate and was named polonium after the name of the motherland of Madame Curie. In December, 1898 the discovery of radium in the barium sulphate precipitate was announced. This impure radium preparation showed a radioactivity which was million times greater than that of uranium.

A third radioactive element was discovered in the ammonium hydroxide precipitate containing ferric and rare earths compounds by A. Debierne in 1900, who was helping Pierre and Madame Curie. They called this product actinium, which was also independently discovered by O. Giesel (1852-1927), who was a chemist in a quinine factory in Brunswick. It has been reported that Giesel also prepared and sold radium bromide and his own breath was found to be radioactive, although he lived over 25 years after the discovery of actinium. Madame Curie presented her thesis for the D.Sc. degree in the Sorbonne in 1902 embodying her researches on radium and radioactivity, and the same was published in the following year. In 1902 she determined the atomic weight of radium by precipitating 0.09 of radium chloride with silver nitrate and obtained a value of 225 as the atomic weight of radium. Again, in 1907, working with 0.4 of radium chloride, she found the atomic weight to be 226.4 taking silver as 107.88 and chlorine 35.46. The eminent authority on determination of atomic weight, Prof. Honiogschmid of Vienne, in 1911, obtained a value of 225.95. Aston's mass spectograph indicated the value as 226.1. The accepted value today is 226.05. In 1910 Madame Curie and Debierne isolated metallic radium by electrolysing a solution of radium chloride with a mercury cathode. The mercury was separated from the amalgam by distillation.

Radioactivity was intensely studied all over the world, specially by Rutherford (1871-1937) in Canada and England, Soddy (1877-1956), Fajan, Boltiwood, O. Hahn and others. Rutherford studied the activity of uranium and thorium and reported in 1899, that the rays emitted by uranium were of two kinds (i) those stopped by thin sheets of aluminium which he called α-rays, and (ii) the other requiring much thicker sheets of aluminium designated as β-rays, which are deflected by a magnetic field.

Madame and Pierre Curie reported in 1900 that β-rays carry a negative charge. Becquerel, in 1900, by deflection in electric and magnetic fields determined the velocity (1.6×10 cm. per second) and the ratio of charge to mass ($e/m = 3 \times 10^{17}$ e.s.u./g of β-rays). These values are of the same order of magnitude as those for cathode rays. Strutt (4th Baron Rayleigh) in 1901 and Crookes in 1902 suggested that α-rays were positively charged particles of relatively large mass. This was confirmed by Rutherford in 1903. Villard discovered the rays which were called γ-rays by Rutherford. They are more penetrating than β-rays and are not deflected by magnetic field.

In 1910 Madame Curie could prepare one gram of radium from pitchblende after great efforts and presented this valuable material to her laboratory. In 1920 she was invited by the women of America and many honorary degrees and distinctions were showered upon her, and the women of America subscribed for the purchase of another gram of radium for her institute.

Madame Curie, First Woman Professor of the Sorbonne and twice Recipient of the Nobel Prize

In 1903 the Davy Medal of the Royal Society of London was awarded to Professor Pierre and Madame Curie. The Nobel Prize of 1902 in Physics was first awarded to Prof. Becquerel and Pierre Curie, who represented to the Nobel Committee that the discovery of radium was as much due to him as to Madame Curie, and, the Committee agreed to award half of the Nobel Prize to the husband and the other half to the wife. In April, 1906 Pierre Curie was killed in a street accident in Paris. The authorities of the University of Paris appointed Madame Curie as Pierre Curie's successor to the Chair of General Physics at the Sorbonne. This was the first time that a woman was appointed as University Professor. In 1911 Madame Curie was awarded the Nobel Prize in Chemistry. Thus she was the only recipient of the Nobel Prize twice in science.

Since 1900 the physiological effect of radium rays was investigated by the Pasteur Institute of Paris and the Paris University jointly established a radium institute known as Pavillon Curie with Madame Curie as the Director of Physical Sciences, which was ready for occupation in July 1914-1918. Madame Curie installed X-ray equipment for military purposes in 20 motor cars and 200 hospitals in different parts of France for the trreatment of the wounded.

From her research institute 483 scientific communications of which 34 were theses and 31 publications in the name of Madame Curie appeared during the period 1919 to 1934. Doctor Reguad, Director of the Biology and Medicine Branch of the Pavillon Curie treated 8,319 patients from 1919 to 1935. Baron de Rothschild and Lazard Freres and an annonymous donor contributed 3.5 million francs to the Curie Foundation.

Life Pension Sactioned by French Government in 1923

On December 26, 1923, i.e., 25 years after the discovery of radium, the French Government voted 40,000 francs as annual pension to Madame Curie with the right of inheritance to her daughters Irene and Eve.

Prof. Regaud wrote: 'Madame Curie can be counted among the eventual victims of the radioactive body which she and her husband discovered'.

Death of Madame Curie caused by Radioactive Emanations

In 1934 she became seriously ill and proceeded to the Sancellemoz Sanatorium where she died. The Officer-in-Charge, Doctor Tobe recorded: 'The disease was a plastic pernicious anaemia of rapid, feverish development. The bone marrow did not react, probably beacuse it had been injured by a long accumulation of radiation'. Due to constant exposure to the highly toxic rays from radioactive substances investigated by them, Irene and her husband also died prematurely.

Madame Curie – a brilliant Director and Lecutrer

Prof. Einstein stated: 'Marya Curie is of all the celebrated beings the only one whom fame has not corrupted'.

I had the honour of working in her institute for two years – 1917-1919, and I found that she took great pains in preparing university lectures with experimental demonstrations in which her daughter Irene helped her. After receiving the Nobel Prize with her husband, Prof. Curie Joliot, Irene visited different countries and visited India in 1950.

Prof. Jean Perrin, the Nobel Laureate, who was also my teacher, frequently stated: 'Madame Curie is not only a famous physicist, she is the greatest laboratory director I have ever known'. During this period a galaxy of brilliant mathematicians and scientists, Henri Poincare, Appel, Painleve, Le Chatelier, Bouty, Lippmann, Haller, Behal, G. Bertrans, Roux, Delepine, Caullery, Urabain, Langevin, Duclaux, Job, Matignon, Jungfleisch, Pierre and Madame Curie, Mouton, Fabry, D. Berthelot, Moureu, Dufraisse, Grignard, Fournier and others were teaching in Paris.

ATOMIC DISINTEGRATION

The collision of fast α-particles, protons, deuterons or neutrons with atoms of other elements may cause the breaking of the nucleus. Rutherford reported in 1919 and 1920 that nitrogen exposed α-particles emit long range protons which came from the nitrogen nucleus. Similarly, Rutherford and Chadwick in 1921, Blackett in 1922 and Harkins and Ryan in 1923 demonstrated the disintegration of atoms by the cloud chamber method. When α-particles having mass 4 and charge 2 bombard nitrogen atom, mass 14 and nuclear charge 7, they enter the nucleus producing a particle of mass 18 and nuclear charge 9, which is an isotope of fluorine. This nucleus emits a proton, mass 1 and charge 1, producing a nucleus of mass 17 and charge 8, which is an isotope of oxygen. In 1932, Cockroft and Walton disintegrated lithium into helium. This was the first artificial atomic disintegration by bombardment with high energy protons from hydrogen ionised in a discharge tube and accelerated by high potential difference. In 1933, F. Joliot and Irene Curie observed that both positive and negative electrons are emitted by thin layers of berylium, boron and aluminium bombarded by particles from polonium. In 1934, they reported that the emission of positron persisted even after the removal of the source of α-particles. This was the first discovery of artificial radioactivity.

Fission of Uranium to Barium by Otto Malhn and Influence of Chemical Evidence in Fission

E. Fermi and collaborators, by bombarding uranium, atomic number 92, with slow neutrons obtained by passing through water or paraffin wax, thought that they had obtained an element of atomic number 93. They reported similar results with thorium in 1934, but Frau Ida Noddack criticised Fermi's chemical evidence and stated: 'It

is conceivable that in the bombardment of heavy nuclei with neutrons, these nuclei break up into several large fragments which are actually isotopes of known elements, not neighbours of irradiated elements'. O. Hahn and Strassmann in 1938, by co-precipitating the solution of the product of the bombardment of uranium with neutrons with a barium salt solution, thought that they had obtained an isotope of radium. After β-ray decay, the products of the bombarded material were precipitated with lanthanum. Hence, the authors regarded them as the actinium isotopes. Madame Joliot Curie and Savitch, in 1937, reported that the bombarded product concentrated with lanthanum rather than with actinium.

Early in 1939, Hahn and Strassmann concluded that their supposed radium was actually barium, and from chemical evidence they concluded that their actinium and thorium were really lanthanum and cerium. The authors stated that their experimental results contradicted the accepted views in nuclear physics. Lise Meitner, who was a collaborator of Prof. Hahn for a number of years in Berlin, and O.R. Frisch, in 1939, reported that nuclear physics must give way to chemistry and stated: 'On the basis of present ideas about the behaviour of heavy nuclei, an entirely different and essentially classical picture of these new disintegration processes suggests itself. It seems possible that the uranium nucleus has only small stability of form and may, after neutron capture, divide itself into two nuclei of roughly equal size.

It was soon discovered that the fission of uranium by neutrons liberates a large amount of energy according to Einstein equation: $E = Mc^2$ where E = energy liberated; M = mass destroyed and c = the volocity of light. Both isotopes of uranium U_{235} and U_{238}, are split by fast neutrons but U_{235} is broken up by slow neutrons. In this process, more neutrons are liberated, but the fast neutrons escape quickly and it is only the slow neutrons which are effective for breaking U_{235} and the creation of an atomic bomb.

Discovery of Transuranium Elements

In modern times increased neutron fluxes are being achieved as nuclear reactors are improving and 12 new elements beyond uranium have been isolated. The first four of these transuranium (94), americium (95) and curium (94), americium (95) and curium (96) can be manufactured in kilograms whilst californium (98) in grams. The chemistry of berkelium (97) has been studied with submicrogram amount and, hence, this element along with einsteinium (99), fermium (100), has only been obtained in traces. The elements upto fermium (100) are formed from U_{238} by succession of neutron capture and β-ray decay as shown by the reaction leading to the discovery of neptunium and plutonium.

It has been found that elements of atomic number of 100 or more decay by spontaneous fission with very short half life, so that their preparation cannot be achieved by exposing uranium or transuranium elements to a reactor or

more rapidly by exploding a thermo-nuclear device in a suitably sealed underground cave and processing the debris. Such elements are prepared by bombarding plutonium, curium or californium with boron, carbon, nitrogen, oxygen or neon ions accelerated in a cyclotron or linear accelerator. The yields of mendelevium (101), nobelium (102), lawrencium (103) and element 104 are extremely small. Along with transuranium elements, fair amounts of technetium (43) and promethium (61) are formed as fission products in nuclear reactors. Polonium 210 and actinium 227 can be readily synthesised by neutron irradiation of bismuth and radium respectively.

Atomic Fission Markedly Increases Production of Highly Dangerous Radioactive Materials

Before the fission of uranium by neutron in 1939, the amount of radioactive matter in use in the hospitals and laboratories throughout the world was only equivalent to a few hundred grams of radium of atomic weight 226. Today, a low power (10 megawatt) nuclear reactor fed with natural uranium will produce fission products giving out α-radiations equivalent to one ton of radium together with α-particles emitting transuranium elements equivalent in activity to 200 grams of radium. The generation of large amount of radioactivity is highly hazardous and the investigations of the chemical properties of the new elements are not straightforward because of their radioactivity, which is more intense for the higher elements. The radiations emitted have two important consequences relating to health hazard and to their chemistry. The first is that they are among the most toxic substances known to man because of the irreversible damage to tissue caused by such materials. When ingested, they are selectively retained in critical organs in the body. Plutonium, for example, tends to concentrate in the bone; other elements in the series are retained in the kidneys or in the gastrointestinal tract. The high toxicity becomes immediately apparent when one compares the maximum permissible concentrations per cubic metre in air for continuous exposure, assuming a 40-hour week with those for the more conventional poisons. The figures for carbon monoxide and hydrocyanic acid are 100 mg and 10 mg respectively while those for ^{239}Pu and ^{241}Am are 3.1×10^{-8} mg and 1.8×10^{-9} mg respectively many orders of magnitude smaller than those for hydrocyanic acid.

Chemistry played a major part in the discovery of fission process by identifying barium as one of the products of thermal-neutron bombardment of uranium. Chemical processes have also played an essential role in the application of the fission process to the production of nuclear power. These processes involve the treatment of several thousand tons of uranium per annum; this tonnage is comparable to that of the metals, mercury and silver, substantially lower than elements such as arsenic, tin and nickel, yet rather larger than gold, beryllium and tantalum.

Two sequences of chemical processes are involved. In the first, ore concentrates

(largely U_8O_3) are converted to nuclear fuels, uranium metal or dioxide. In the second, the nuclear fuels, after removal from reactors, are treated for the recovery of useful constitutents, such as plutonium or fission-product strontium. The radioactivity in the first category is relatively low, but in the second very high.

Thorium as Fissionable Material

Since the application of uranium in atomic fission as a power source has been developed to such an extent, attention has been directed to thorium which is more abundant in nature than uranium, as a possible source of the secondary nuclear fuel U^{233}. According to J. Paone (1960) an important potential use of thorium is its application in the field of nuclear energy. By the capture of slow neutrons Th^{232} is converted to Th^{233} a negative beta particle being emitted with a 23-minute half life. The product of Th^{232} is protoactinium, which is also beta active with a half life of 27.4 days. It decays into fissionable U_{233} and a long lived α -particle with 1.63×10^5 years half life. Thus, the thorium nucleide, upon bombardment by thermal or slow neutrons, becomes eventually a potential nuclear fuel material capable of initiating a chain reaction. Nuclear reactions employing a blanket of thorium around the reactor are capable under certain conditions of producing as much and possibly more fuel than is consumed in fission. A number of major reaction projects proposing to use thorium have been under way for several years in the USA.

Atomic Energy not yet in the Picture of World Energy Resources

The discovery of the neutron fission of uranium to barium and opther elements in 1939 by Prof. Otto Hahn with liberation of tremendous energy has led to fabulous activity and expenditure all over the world for obtaining atomic energy for the use of man. But, uranium occurs on the earth's surface to the extent of 4 grams per ton of the earth's crust, whilst thorium, another fissionable element, is three times more abundant. Moreover, 0.7 per cent of natural uranium is uranium 235 which actually breaks up in energy production. Although, 12 new transuranium elements have been synthesised in the last 26 years, the consensus of expert opinion seems to be that even on the basis of the most optimistic assumption about the future rate of nuclear developments, the contribution of atomic power until 1975 to growing energy demands will be marginal. (*The Petroleum Handbook*, 4th edition, London, 1959, page 20).

'Nuclear power offers no panacea for the world's energy problems. The adoption of fission power will be slow and its rate will depend ultimately on the exhaustion of fossil fuel reserves. Fusion power, while potentially having many advantages over fission power including an inexhaustible fuel supply for negligible cost, has not yet been established as feasible and its costs cannot be reliably assessed. Both types of nuclear power are uniquely adapted to the generation of electrical power and less so to the production of other forms of energy, such as those now used in

comfort and process heating or in land transportation. Thus, a radical change in existing energy consumption patterns is required before the fossil fuels are finally enhausted.' (Robert C. Axtmann, pp. 488-495 in *The Population Crisis and the Use of World Resources*, edited S. Mudd, 1964, The Hague, Dr W. Junk, Publishers).

Beginning of Atom Bomb

After the beginning of the Second World War in 1939, Prof. Otto Hahn of Berlin approached Hitler and informed him that he was in a position to manufacture a powerful bomb from his discovery of atomic fission. Hitler asked him how much time he would take for this purpose and Hahn replied that it would take two years. But, Hitler was impatient and he stated that he had no use for a discovery which cannot prolduce tangible result within six months.

On the other hand, after the occupation of Denmark by Hitler, Neils Bohr, the great Danish atomic physicist had to leave his own country for USA as he was a Jew. But, before he left Denmark, he discussed the details of atomic fission with Lise Mertner who was associated with Hahn in atomic fission studies and who being a Jewess was on her way to Sweden from Berlin. After reaching USA, Bohr contacted A. Einstein, who also was of Jewish origin and a Professor in the Princeton University as a nautralised American citizen. These two great men discussed the fabrication of the atomic bomb and Einstein wrote to President Roosevelt to take up this work. Roosevelt consulted Churchill, the Premier of the United Kingdom, who was encouraged by Lord Cherwell (Prof. Lindemann), Churchill's scientific adviser. Also, Churchill sent some of his able atomic pysicists, mathematicians and engineers to join the USA experts. This tremendous undertaking, which was extremely difficult in execution, resulted in the construction of atomic bombs under the leadership of R. Oppenheimer, another Jew from Germany and settled in the USA. Under the Presidentship of Truman, the two bombs fell on Hiroshima and Nagasaki in 1945, and, thus, began the atomic age with all its complications and dangers.

Acharya Jagadish Chandra Bose: His Life and Work (1858-1937)*

D.S. KOTHARI
Chairman
University Grants Commission
New Delhi

ACHARYA Jagadish Chandra Bose occupies a high, almost unique, place in the recent history of Indian science. He was an investigator of uncommon courage, resourcefulness and dedication. Bose's scientific work broadly falls under three periods. From 1894 to 1899 he was almost entirely concerned with the study of electric waves; between 1899 and 1902 he shifted from the physical to the biophysical field, and beyond 1903 he was occupied with the study of plant-responses under physical stimuli of various types. For these studies he developed and constructed his own instruments which were remarkable for their originality and extreme sensitivity. Bose founded the Bose Institute in Calcutta in 1917. He continued to be the Director of the Institute till his dealth in 1937. Bose visited Europe many times, and America twice, on lecture tours. He was elected a Fellow of the Royal Society in 1920, and Corresponding Member of the Academy of Sciences, Vienna, in 1929. He was the General President of the Indian Science Congress in 1927. He served on the Council for Intellectual Co-operation of League of Nations from 1926 to 1930.

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Bose was born on November 30, 1858, in the town of Mymensingh in East Bengal**. (His father, Bhagwan Chandra Bose, was at the time Duputy Magistrate of the place). He died on November 23, 1937, at the age of 79 years. (He was survived by his wife Smt. Abala Bose. She was the daughter of Shri Durga Mohan Das, a leading advocate of the Calcutta High Court). He received his primary education at the local school at Faridpur; his father did not send him to the English school which was there in the same town. Later, he joined the St. Xavier's School in Calcutta, and the College, from which he graduated at the age of 20. He subsequently went to England and joined the London University to study medicine. He attended some lectures by the famous zoologist, Ray Lancaster. Due partly to reasons of health, he left London to join the Christ College at Cambridge. He studied for the Natural Science Tripos, and attended lectures, amongst others, by Lord Rayleigh (Physics). He took the Tripos (Cambridge) and B.Sc. (London) in 1884. On his return from England he was appointed Professor of Physics in the Presidency College, Calcutta, in spite of serious opposition from the then Education Department. Bose had to do as much as 26 hours of lecture and

* Reprinted from 'School Science', Vol. 3, No. 1, March 1964
** Now in Bangla Desh

demonstration per week. (This was much more than what was normal for his British colleagues in the same college). He retired from the college in 1915.

Acharya Jagadish Chandra Bose (1858-1937)

It was probably at the age of about 35 that Bose seriously made up his mind to dedicate himself completely to the pursuit of science and scientific research. No grant at the time was available to him for research work. The laboratory in the Presidency College, Calcutta, was poorly equipped and sometimes Bose had to construct his apparatus from his own personal resources. It was several years later that the Government sanctioned for his work in the college an yearly grant of Rs. 2,500. Bose's earliest research work was concerned with electric waves and their interaction with matter. Electric waves were first produced in the laboratory by Heinrich Hertz in 1888 in his epochal experiments. The existence of these waves had been predicted by Maxwell about 20 years earlier on the basis of his extremely far-reaching and extraordinarily fruitful (as later work showed) electro-magnetic theory. It has been sometimes said that Bose was led to the study of electric waves, after reading a paper by Sir Oliver Lodge on 'Heinrich Hertz and has Successors' (1894). From the very beginning Bose's remarkable physical insight, and his superb ingenuity and resourcefulness in experimentation were apparent. He succeeded in generating waves of wavelengths much smaller than what Hertz and others had done. He produced waves of about half-a-centimetre in wavelength. Because of this he was able to investigate in considerable detail the 'optical' properties of electric waves, such as refraction, polarisation and double refraction. He determined the refractive indices of many substances and also investigated the influence on total reflection of the thickness of the air-gap between two dielectric slabs. In the paper published in the *Proceedings of the Royal Society* in November, 1897, he observed "It is seen from the above, that as the thickness of the air-space was gradually increased, the reflected component increased, while the transmitted portion decreased. Minimum thickness for total reflection was found to be 8 mm". He also verified that the

thickness of the air-gap, for which total reflection disappeared, increased with the wave-length. It may be mentioned that Bose's first paper entitled 'On Polarisation of Electric Waves by Double Refracting Crystals' (he tried beryl, rocksalt, etc.) was published in May, 1895, in the *Journal of the Asiatic Society of Bengal*. In 1897 Bose gave a lecture at the famed Royal Institution, London. It is interesting (and also instructive) to recall that the demonstration apparatus exhibited at the lecture, which in present-day terminology may be described as a (simple) microwave spectrometer complete with transmitter and receiver (improved type of coherer), was constructed in Calcutta and taken by Bose with him to London. The originality and simplicity of the apparatus employed by Bose in his experiments were most remarkable. For instance, he demonstrated the polarisation of electric waves by the simple device of 'interleaving the pages of a Bradshaw railway time table with sheets of tin foil'. Again, to eliminate the undesirable reflections of electric waves in tubes employed to guide them (as in the case of spectrometer), he tried many different coatings — in other words, he was searching for an absorber of microwaves. He found that blotting-paper dipped in electrolyte gave the best results. 'Bose, in India between 1895-97, used hollow tubes of either circular or square section as wave-guides and wave-guide radiators on wavelengths between 5 mm and 2.5 cm. His adaptation of hollow tubes was probably based on the used of metal tubes in telescopes and microscopes'.* Bose also employed conical horns —he called them collecting funnels—for concentrating the waves on the detectors. He studied the rotation of the plane of polarisation, and found that a bundle of twisted jute fibres gave right or left-handed rotation depending on the right or left-handed twist of the fibres. This constituted a 'large-scale or *macro* demonstration' of the optical phenomenon of the rotation of the plane of polarisation.

For the detector, Bose used the coherer discovered by Branly and Lodge. He made considerable improvements, particularly in sensitivity and reliability. He also experimented with the point-contact-type detector consisting of a metal wire in contact with a metal plate or semi-conducting crystal. In the case of most substances, the resistance falls when the detector is exposed to electric waves but there is also a rise of resistance for some substances such as lead peroxide and potassium. Bose found that in the case of galena crystal the detector was not only sensitive to electric waves but also to light radiation extending from infra-red to violet. Here, he was obviously dealing with what later came to be recognised as photovoltaic effect. These experiments dealing with the variations in contact resistance under the influence of electric waves—particularly the erratic behaviour of the system in many cases—brought to Bose's mind the phenomenon of electric response in

* J.F. Ramsay, 'Microwave Antennae and Waveguide Techniques before 1900' *Proc. I.R.E.*, Feb., 1958.

animal muscle when subjected to stumuli. 'Bose enquires whether inorganic models may not also be devised which will satisfy this criterion. In this way he was able to construct models in which mechanical and light stimuli produce electrical responses. The proportionality which exists between intensity of stimulation and electrical response, the gradual appearance of fatigue in response after repeated stimulation, from which the system recovers after it is given sufficient rest, the increase of response on treatment with one set of chemicals and its inhibition by another set, are similar to what occurs in living tissues. We shall describe here only one of his models : it is made of two wires of pure tin, whose lower ends are clamped to an ebonite block; the upper ends pass through an ebonite disc, and are joined through binding screws to the two terminals of a sensitive galvanometer. The arrangement fits into a cylindrical glass vessel, filled with distilled or tap water. On giving one of the tin wires a sharp twist, an electric current flows from the wire through the galvanometer system. The amplitude of response is enhanced when a small quantity of sodium bicarbonate is added to the distilled water; on the other hand, if oxalic acid is added to the water the response is abolished. Many of the effects observed in animal tissues under stimulation, viz., of the opposite effects of small and large doses of a chemical poison, etc., could be obtained with this model of Bose.* Mention here may also be made of the interesting analogy between the excitation of nerve and the passivity of iron dipped in strong nitric acid. This was investigated in great detail by Lillie (1920-36) and later by Bonhoeffer.** The first suggestion came from W. Ostwald in 1901. Another interesting model is due to Bredig (1903-1908) in which the oscillations of a mercury drop placed in a hydrogen peroxide solution appear (outwardly) to resemble the rhythmic pulsations of an animal heart.

These investigations gradually led Bose to the formulation of his fundamental concept (and in this context it is relevant to call attention to his early training in physiology and medicine) that basically the response, under stimulus, in the non-living (e.g. metal) and the living (e.g. animal muscle) is of the same nature, though they differ in their level of complexity. From about 1903 onwards Bose investigated with great ingenuity, vigour and perseverance the response phenomena in plants when exposed to various kinds of stimuli, e.g. mechanical, electrical and chemical and also light radiation. He regarded that the response phenomena in plants lie between those exhibited in inorganic matter and in animals. He developed and constructed in his own laboratory special instruments for the purpose of measuring almost every type of plant response. The rate of growth of plants is, crudely speaking, of the order of 0.1 –

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* D.M. Bose, Jagadish Chandra Bose: Birth Centenary Series III. *Science and Culture*, 24, 5 (1958). p. 215.

**R.R. Bonhoeffer, 'On the Passivity of Iron'. *Corrosion*, II (1955). See also R. Fatt, 'Physics of Nerve Processes'. *Reports on Progress in Physics*, XXI. (1958), p.112.

0.01 mm per minute, and to measure that he constructed many instruments which he named *Crescographs (crescere:* to grow). The high-magnification *crescograph* consisted of a combination of levers (in some cases mechanical and optical) giving a magnification of about 10,000. The magnetic *crescograph*, in which the small displacement of a magnet caused a large deflection in a static magnetic system, produced a magnification of more than a million. Bose also developed several types of automatic recorders in which friction between the recording pan and the writing plate was eliminated by either vibrating the plate or the stylus. He constructed an instrument to record the liberation of oxygen during photosynthesis in plants. He also studied the variations, as a result of stimulations, in the electrical resistance of plant tissue. He was the first to use electric probes for the localisation of actively metabolising layers in plants.

Bose's plant work was largely carried out with the *Mimosa* plant and with *Desmodium gyrans* (telegraph plant, the Indian name is *bon chural*). He studied even such things as the effect of load (placed on the leaf) on response to stimulus. For instance, he observes: 'The effect of load on the response of *Mimosa* is similar to that on the contractile response of muscle. With increasing load the height of response undergoes a progressive diminution with shortening of period of recovery. Within limits, the amount of work performed by a muscle increases with load. The same is true of the work performed by the pulvinus of *Mimosa*'. In the case of Desmodium gyrans he observed that the detached leaflet continued to show rhythmic pulsations, the period being of the order of two minutes. The pulsation occurs between the temperature of about 17°C and 45°C. The pulsation is affected by chemical reagents and electric stimuli. Bose also investigated the problem of the ascent of sap in plants. He thought, contrary to the generally accepted view then and now, that this is brought about by peristaltic activity of the inner cortical cells in the plant stem, somewhat analogous to the activity of the animal heart.

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It may be observed that one of the most far-reaching concepts which has emerged from the biological and physiological researches during the present century is that all vital processes in living organisms can be (completely) understood in terms of physical and chemical laws governing material phenomena. (It appears – some think it is certain that this is not likely to be the case in the realm of phenomena concerning the mind). Towards this realisation Bose made a pioneering and very important contribution. In one of the papers read (but not published) before the Royal Society in 1904 he observed: 'From the point of view of its movements a plant may be regarded in either of two ways: in the first place, as mysterious entity, with regard to whose working no law can be definitely predicted, or in the second place, simply as a machine, transforming the energy supplied to it,

in ways more or less capable of mechanical explanation. Its movements are apparently so diverse that the former of these hypotheses might well seem to be the only alternative. Light, for example, induces sometimes positive curvature, sometimes negative. Gravitation, again, induces one movement in the root, and the opposite in the shoot. From these and other reactions it would appear as if the organism had been endowed with various specific sensibilities for its own advantage, and that a consistent mechanical explanation of its movements was therefore out of the question. In spite of this, however, 'I have attempted to show that the plant may nevertheless be regarded as a machine, and that its movements in response to external stimuli, though apparently so various, are ultimately reducible to fundamental unity of reaction'.* And further, to quote from his book, *Plant Response as a Means of Physiological Investigation* (1906): 'The phenomenon of life, then, introduces no mystical power, such as would in any way thwart, or place in abeyance, the action of forces already operative. In the machinery of the living, as in that of the non-living, we merely see their transformation, in obedience to the same principle of conservation of energy as obtains elsewhere; and it may be expected that, in proportion as our power of investigation grows, the origin of each variation of the living organism will be found more and more traceable to the direct or indirect action upon it of external forces, the element of chance being thus progressively eliminated, as the definite sequence of cause and effect comes to be perceived with an increasing clearness; and only, I venture to think, as this is worked out, can we learn to apprehend fully the true significance of the great Theory of Evolution'.

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In his papers and books Bose gives very few references to previous and contemporary workers. This is partly, no doubt, due to the fact that he was in most cases exploring new ground. It should also be mentioned that 'the priority of many of Bose's observations, e.g. positive and multiple responses, alike electrical and mechanical, and transmission of death excitation, is seldom given the acknowledgement due, in current literature on plant physiology… He has left behind nineteen volumes which form a record of the work carried out and directed by him over a period of nearly thirty seven years. Bose was truly a great man of science and his pioneering spirit and work have played a vital role in the revival of scientific research in our country. But for all this he was more in the nature of a lone worker — a towering but isolated peak- rather than a builder himself of a school of scientific research. To conclude we may quote his memorable words spoken at the end of the lecture at the Royal Institute (London) in January, 1897: 'The land from which I come did at one time

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* 'Plant Response as a Means of Physiological Investigation' by Sir Jagadish Chandra Bose (1906), p.viii.

strive to extend human knowledge, but that was many centuries ago. It is now the privilege of the West to lead in this work. I would fain hope, and I am sure I am echoing your sentiments, that a time may come when the East, too, will take her part in this glorious undertaking; and that at no distant time it shall neither be the West nor the East, but both the East and the West, that will work together, each taking her share in extending the boundaries of knowledge, and bringing out the manifold blessings that follow in its train'.

Geddes in his 'Life of Bose' gives the following extract from the *Spectator* (London) : 'We can see no reason whatever why the Asiatic mind, turning from its absorption in insoluble problems, should not betake itself ardently, thirstily, hungrily, to the research into Nature, which can never end, yet is always yielding results, often evil as well as good, upon which yet deeper inquiries can be based. If that happened – that would be the greatest addition ever made to the sum of mental force of mankind'.

Nearly 100 years after Guglielmo Marconi's first transatlantic wireless communication, a group of scientists of the US-based Institute of Electronics and Electrical Engineers (IEEE) have reported that – "the origin and first major use of the solid state diode detector devices led to the discovery that the first transatlantic wireless signal in Marconi's world famous experiment, in 1901, was received by Marconi using the iron-mercury-iron coherer with a telephone detector invented by Sir J.C.Bose in 1898".

(*Editor*)

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Assessment of Learning and Acquisition of Scientific Temper

N. Panchapakesan
Retired Professor
Department of Physics and
Astrophysics, University of Delhi
K-10, Hauz Khas Enclave
New Delhi 110 016.

We are at the end of the year 'World Year of Physics'. It celebrates the centenary of Albert Einstein's 'Special Theory of Relativity' given in 1905. It is said that this theory removes absolutism and brings in the idea of relativism. Every inertial observer has his own time and event simultaneities. No one observer is special in any way. Put another way, everyone is unique! Philosophers say that this (along with other events) has led to ethical relativism. No one wants to take a definite stand against or for any absolute value or principle. But Einstein's theory of relativity also pointed out and discussed invariances and covariances which exist in the universe. Universal and relative concepts live together.

This is what we need to keep in mind when we look at any problem, including Assessment. There is a common level of objectives and aims and at the same time each learner has his own space-time, his own world. These distinctions become very important when we have institutional frameworks for imparting education. Even in the best of cases, the aims of persons in different segments or layers of the system are not identical. Perceptions vary widely depending on the environment. A teacher is not perfect. She has to worry not just about communicating but also about her students doing well in the examinations. To remove subjective distortions, a fairly inflexible system is set up and adhered to meticulously, almost obstinately. The result is often counter- productive to the aims of education. If the society or the system was perfect, as envisaged by a theoretical model, then there is no problem. However in a realistic, human situation, there are deviations, departures, imperfections, which can be ignored only at our peril. What we need is a perception, an understanding of the deviations (imperfections ?) in any given situation. By definition these can not be modeled in an ideal or perfect way.

This is where 'Science Education' ceases to be a 'natural science' and becomes a 'social science' with all its heartaches and uncertainties. We look at the qualitative differences between the natural and social science. Acquiring scientific temper is akin to learning values and is really a part of social science. Science education has very little to do with developing a scientific temper. The discussion will be against the background of the 'Hoshangabad Science Teaching Programme' which ended in Madhya Pradesh a few years ago.

1. Introduction

It is ironic that I should have been chosen to speak on assessment. I have

a great aversion to judging people. I have not been on any committee or group involved with the NET examination of the UGC or CSIR or the admission committee in my department. It is not that I have refused to do these things, but I was never asked. Maybe others guessed my reluctance or had doubts about my competence. But somehow I got involved in assessment with HSTP.* Students were doing so badly that it was decided that they should be marked on the curve. I came up with simple minded analysis of marks which could then be modified to get a decent distribution (sophisticated fudging !). Otherwise all the students were in a pile at the bottom. This was more than 25 years ago. After that the HSTP has grown and I am sure, changed. I do not know if the analysis was changed, modified or continued. Anyway that is the only justification for my standing before you, talking about assessment in schools. Of course, I have been forced to assess my own students at the university.

My first observation follows naturally from what has been said above. The source group in HSTP had (or liked) to do things they were never qualified for, but had secretly wanted to do ! We had people getting interested in drawing sketches, designing book lay outs etc. In many cases their efforts were very creative, good and successful. That is something the formal systems never encourage or permit. I think that is a plus point for People Science Movements like HSTP.

*Hosangabad Science Teaching Project

2. Imperfect Institutional Frameworks- Need More Assessments

My main theme in this talk is that the time has come for the workers in the field of education to go to the second stage. The first stage was to agree on child centering. The National Curriculam Framework (NCF) has already done that. However, child centering is an ideal concept. It requires perfect conditions, low student teacher ratio, highly qualified and motivated teachers etc. Going to the second stage is to recognise the imperfections and try to work in a non ideal system. A lot of optimisations will have to be done. We might recall that whatever progress the subject of economics has made, is because of the recognition of imperfect markets and imperfect competition, and not working with the idea of a hidden hand of Adam Smith. A physical law is same for every observer but each observer uses his own space- time to work in.

Start with an example. A class has 30 students instead of 5 or 6. Then :

- It is necessary to have students in groups of 5 or 6.
- One needs attendance registers
- One needs submission of class and home work and its correction and evaluation.
- One needs periodic and final evaluation.

None of this is needed if one had a very small number of students.

Let us take an example from HSTP of 30 years ago.

- Unqualified Teachers
- Absence of Kit
- Ignorance of Decimals
- Non Suitable examination
- Lack of language fluency among students

These were addressed by

- Having monthly meetings with teachers
- Getting involved in designing/ purchasing and distributing Kit.
- Writing and including a chapter on Decimals.
- Designing and conducting examinations in theory and practicals.

Linguistic Ability could not be addressed. It was way out of our ambit. Many other problems were never tackled though one was aware of them. Some of these were

- Parental anxiety about doing well in Medical (PMT) and Engineering (JEE) entrance exams.
- No substantial advantage offered by HSTP in performance in 9th Class and above.

The old system may not be good education but over the years an informal parallel system of well checked guidelines and suggestions has developed on how to score highly in examinations!

3. Assessment—An Overview

The topic of this paper is an important part of educational policy and has been discussed ably in the National Curriculam framework (NCF). It may be useful to begin with what they say and their conclusions. By and large they are non controversial.

"Education is concerned with preparation for meaningful life and evaluation should provide feedback on the success in implementing such an education. Current processes of assessing a very limited range of faculties are highly inadequate. Even the limited purpose of providing feedback on scholastic and academic development can be achieved only if the teacher is prepared before the course of teaching with the techniques of assessment, the parameters of evaluation and the kinds of tools that will be employed. In addition to judging quality of student's achievement, a teacher has to collect analyse and interpret performance on various items of assessment to understand the learning in different domains. **The purpose of assessment is to improve teaching-learning process and materials, and to review the objectives one began with, in the light of capabilities of learners as revealed by testing.** In the evaluation of learning we should also have parameters which encompass creativity, innovativeness, development of the whole being, attitudes to learning and ability for independent learning. Assessment and examinations must be

credible and based on valid ways of gauging learning." (emphasis has been added and considerable editing has been done)

The examination reform committee, associated with NCF, had recommended Continuous and Comprehensive Evaluation (CCE) coupled with teacher empowerment. The NCF, however, urges caution as CCE places a lot of demand on the teacher's time and ability to maintain records. This is an example of what I would like to call recognising imperfections on the ground. CCE is both good and bad. Niels Bohr, the famous physicist had several famous arguments with Albert Einstein and often came out victor. He said "A great truth is one for which the truth and its opposite, both are true". CCE seems to fall into that category. Social science is full of great truths! (Physics has only a few, like Particle — Wave duality.)

The Examination reform committee also gives suggestions on nature of questions which should be asked. Their detailed recommendations on different ways of testing different classes (in the context of CCE) can be very useful, if not used rigidly or forcibly. It is made quite obvious at various places that making of tests ensuring their reliability, credibility and validity is a specialised job requiring professionals. The scarcity of such professionals is a matter of deep concern in our country. The corporate sector also needs evaluation instruments. They are now coming into the country as part of collaborations with foreign institutions. There is however a total lack of indigenous effort in creating instruments for academic testing.

4. Scientific Temper, Science and Spirituality (or Religion)

Before we can discuss scientific temper we have to deal with the difference between natural science and social science. (sometimes referred to as hard and soft science) This requires a brief review of the world view of a person and the place of different types of knowledge in that world view. Broadly speaking, we can talk of an inner and an outer world for a person.

I, the thinker, am at the centre of the inner world. I receive continually, from birth, perceptions which serve to define my world view. Free will or capacity to make a choice is assumed. In deciding or making a choice, one needs a value system, part of which is inborn and part comes from outside due to parental and other societal influences, including, of course, faith or religion. The ordering of one's perceptions defines a flow of time, a personal time which can be related to physical time of the outside world. Communication with the outside world by speaking, listening, reading (use of language) coupled with logic enables the construction of the outside world. As is clear the centre of description of the inner world is oneself. The details of many of the above processes, like construction of outside world, are subjects of study in themselves. Every generation of philosophers re-examine and write treatises on them.

The *outer world* is the objective or impersonal world which existed before my birth, holds me in it now and will continue to exist after my death. It is the world of physics and other sciences.

Emotion or feeling does not enter into the impersonal description of the outside world. Logic and scientific method (repeatability, falsifiability) are necessary. This world has a universal time and history. It has no preferred or obvious centre and is accessible to every individual through his or her perceptions. Science is related to outer world and decides our knowledge of it, its laws and evolution.

Spirituality is related to inner world. It does not use the scientific method or the intellect directly. If one has to describe it one can say that it is a feeling of nobility, elation, love, bliss guided by emotion or a refined version of emotion, yet seeming to transcend all these.

Working of Inner World

Inner world includes humanities, arts and social sciences and all other areas of outside science. Though this world is not part of science, the scientific method, i.e. logic and reasoning, plays an essential role here. However, repeatability and falsifiability do not exist; as controlled experiments are not generally possible and where possible have large errors or dispersions. Some times the word 'Soft sciences' is used to describe these areas which include economics, sociology, political science, psychology etc. Statistical methods are crucial for their study. To achieve objectivity in the study of these subjects is not easy. Detachment plays an essential role though perfect detachment is not possible. Careful authors declare their individual viewpoints and beliefs to enable the reader to discount subjectivity and bias.

In the inner world heart, rather than the head, is the decider. Love, affection, kindness, elation, ecstasy play big role in decisions. Soft sciences try to deal with such problems in many ways, many of them statistical in nature. There is however the difficult problem of, empirical validity'. In the absence of experimental or mathematical proof, validity is by personal satisfaction. One example is 'Music Appreciation'. Here personal satisfaction is a key factor, though opinions of other experts may also play a role. Personal satisfaction is accompanied by elation or happy feeling and decides our choice of good music. The ultimate in personal satisfaction is what is called by different names: peak experience, cosmic religious feeling, self-actualisation, *brahmananda*, etc.

Peak experience as a guide to truth

The peak experience plays as much role in the outer world of science as in the inner world. This is because scientists are human beings and the creative experience spans both the worlds. The role of peak experience in science has however been difficult to grasp in an unambiguous way. Kepler's laws of planetary motion led Newton to give his theory of gravitation. Kepler was in great ecstasy when he discovered his laws and this convinced him of the correctness of the laws. He was right in this case. However, there were many other conclusions he reached, based on ecstasy, most of which were wrong. So it appears that peak experiences have to be subjected to experimental verification

and validated, before their scientific truth can be accepted.

In the inner world there is no such way of validation. One has to live with uncertainty and try to validate conclusions to the extent soft sciences permit you. The acceptance of authority in the real world, however, does not seem to be based on validity alone. It is a mixture of charisma, social importance and the power wielded by the promoter of the idea. Hence use of logic, touch with reality and scientific method to the extent possible, is absolutely necessary to tell us if the 'emperor has no clothes!'

Logic and reason have been part of social science and philosophy much before modern science developed. Modern science has reinforced the use of logic and reason, now under the name of scientific method, in soft sciences. This makes a person question the commands of priests and religious books, reducing the power of the clergy. In the framework given above there is really no conflict between science and spirituality as they belong to different areas, either outer or inner world. Both are part of my world view, in my mind. There is no body-mind duality.

Scientific Temper

Scientific temper is an attitude to different questions that arise in normal life of a human being. Like believing in superstition, accepting the pronouncements of a religious authority. These are all based on man made rules not scientific laws. 'What your scientific temper is', is hence a part of social science. The acquiring of scientific temper is akin to acquiring values. Science has nothing to do with scientific temper! It is a red herring in science education, though very important for total education. This was seen in the Hoshangabad programme. The real opposition to the new way of teaching emerged only when social sciences were taught differently.

Conserving Biodiversity: An Important Environmental Priority

MONIKA DAVAR
Lecturer, Department of Education
Maharaja Surajmal Institute
C-4, Janakpuri, New Delhi

BIODIVERSITY refers to variety and variability among living organisms, their genetic differences and the ecosystems in which they live. The distribution of living organisms is uneven on the earth because of different environmental conditions. Countries like Brazil, Columbia, Mexico, Indonesia, Peru, Malaysia, Ecuador, India, Zaire, Madagascar and Australia are known as mega diversity countries because of their rich biodiversity. India alone is estimated to have over 45,000 plants and 65,000 animal species. Biodiversity as a national and global resource is extremely valuable. Biological resources once lost cannot be replaced at any cost.

WHY CONSERVE BIODIVERSITY?

The biological diversity of the planet is being rapidly depleted as a consequence of human actions. An unknown but large number of species are already extinct while many others have reduced population sizes. The current extinction problem has been called the 'Sixth Extinction', as its magnitude compares with that of the other five mass extinctions revealed in the geological record. The current extinction is of a more serious nature as species are being lost at a rate that far outruns the origin of new species. Thus conserving biodiversity should be the utmost priority.

Some other important reasons for conserving biodiversity are as follows:-

- **Uses to Humans:** Humans derive many direct and indirect benefits from the wide variety of living organisms. Bioresources include all our food, many medicines, clothing fibers (wool and cotton), rubber and wood. Thus, we have a stake in conserving biodiversity for the resources we use.
- **Future Resources:** As knowledge improves, new bioresources to increase human welfare may be discovered and developed. Many presently under-utilised food crops may become high yielding and disease resistant varieties through hybridisation with wild species. Genetic engineering of micro-organisms' promises further advances in the production of new compounds and medicines. This future potential will be lost if extinction of species continues at a rapid rate.
- **Adapting to Change:** Another great value of the variety of life is the opportunity it gives us for adapting to change. Genetic diversity will enable breeders to tailor crops to new climatic conditions. A multiplicity of genes, species and ecosystems is a resource that can

be tapped as human needs change.

- **Biodiversity as an Asset:** As a country, it is important to protect our unique natural environments. India attracts tourists from all over the world due to its wide variety of plants and animals. The tiger, lotus, and peacock are our national icons. Some plants and animals have religious significance for Indians and are considered sacred.
- **Ecological Services:** Besides serving as an asset to the nation and resource to humanity, biodiversity also provides ecological services. Vegetation acts as a buffer and helps in maintaining movement and storage of water within the biosphere. It also stabilises the climate. Plants prevent soil erosion. Biodiversity also helps in regulating the oxygen and carbon dioxide balance, nutrient and mineral cycling. Thus, the diversity of life needs to be conserved from ecological standpoint also.
- **Interdependence of Species:** In the biosphere, all organisms are interrelated and interdependent. Each species has its own place in the sequence of events even if it does not seem like an important one. If one species is eliminated, it interrupts the flow of processes. This change affects the whole ecosystem to varying degrees depending on the role of the organism. In cases where the species lost is a key one, it can lead to complete breakdown of the whole ecosystem. An example of this is the Baltic Sea. An increase in algal growth and change in fish stocks has occurred leading to undesirable changes in the aquatic ecosystem.
- **Continued Existence of the Planet:** Biodiversity not only provides stability to ecosystems individually but also provides a foundation for the continued existence of a healthy planet. When ecosystems are diverse, there is a range of pathways for primary production and ecological processes such as nutrient cycling, so that if one is damaged or destroyed, an alternative pathway can be used so that the ecosystems continue functioning at their normal level. If biodiversity is diminished, the ecological balance of the whole planet will be disturbed.
- **Research and Monitoring:** Natural areas provide excellent living laboratories for valuable research into ecology and evolution. Unaltered habitats are often essential for certain research approaches, providing controls against which the changes brought about by human activities may be assessed.
- **Human Responsibility for the Planet:** Irrespective of the benefits biodiversity provides, since human beings are the highest forms of life on this planet, they have the responsibility to protect all other species.
- **Ethical Justification:** On ethical grounds also, conserving biodiversity is justified because one

species on earth does not have the right to drive others to extinction. All species deserve respect because they are all components of our biosphere.

There is possibly no single particular argument which on its own provides sufficient ground for maintaining all existing biological diversity. A more pragmatic approach, however, recognises that different arguments namely the utility to humanity, use in maintaining ecological balance, serving as research base, holding potential for future and ethical and moral responsibility of man for continued existence of a healthy planet together provide an overwhelmingly powerful and convincing case for the conservation of biodiversity.

Green Chemistry and Education

Obot, Ime Bassey
Department of Chemistry
University of UYO, PMB 1017, UYO
Akwa Ibom State, Nigeria

GREEN CHEMISTRY has evolved from its roots in academic research to become a mainstream practice supported by academia, industry, and government. While green chemistry encompasses human health and the environment, it is guided by very specific principles of chemical practice. The interest in using green chemistry and its practices has extended internationally to become an alternative to traditional pollute-and-then clean-up industrial practice in developing countries. This evolution is marked by significant contributions from institutions with different goals that are being satisfied through a common mechanism.

What is Green Chemistry?

Green Chemistry is the use of chemistry for pollution prevention. More specifically, it is the design of chemical products and processes that are environmentally benign. Green Chemistry encompasses all aspects and types of chemical processes that reduce negative impacts to human health and the environment.

Green Chemistry provides an approach focused on the principle of moving pollution prevention upstream to change fundamental processes and emphasises the use of chemical principles and methodologies for source reduction.

Why Green Chemistry?

There is no doubt that our lives have been enhanced by chemistry. However, environmental problems such as DDT, (Dichlorodiphenyltrichloroethanal), ozone depletion are all too familiar examples of chemistry gone wrong. In responding to the growing concern, government introduced regulations to limit pollution and exposure to hazardous chemical and materials. Green Chemistry represents a fundamental shift from this model towards a pollution prevention paradigm. Its premise is that a benign process and products presents no risk.

The importance of Green Chemistry as an alternative in the developing world cannot be overstressed. Sustainable development depends on providing goods and services for a growing population without sacrificing environmental quality. Estimates from the United Nations put the world population as high as 10.7 billion people by 2050 and this nearly doubled population creates a huge demand for chemical goods and services in the near future. Much of the growth of the chemical industry is likely to take place in the developing world, coincident with the rising population. However, many of the global environmental impacts attributable to this population growth have ties to chemical processes or products: [1]

- loss of biological species in forest and in water
- ozone depletion
- downstream pollution from unsustainable agricultural practices
- the pollution of fresh and marine waters, further depleting food sources
- the introduction of persistent organic pollutants into the ecosystem
- changing climates, causing as yet unpredictable changes in the hydrologic cycle with manifestations in flood, drought, sea level change, and the spread of infectious diseases.

The Twelve Principles of Green Chemistry [4]

1. **Prevention:** It is better to prevent waste than to treat or clean up waste after it has been created.
2. **Atom Economy:** Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.
3. **Less Hazardous Chemistry Synthesis:** Wherever practicable, synthetic methods should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. **Designing Safer Chemicals:** Chemical products should be designed to effect their desired function while minimising their toxicity.
5. **Safer Solvents and Auxiliaries:** The use of auxiliary substances (solvents, separation agents, etc.) should be made unnecessary wherever possible and innocuous when used.
6. **Design for Energy Efficiency:** Energy requirements of chemical processes should be recognised for their environment and economic impacts and should be minimised. If possible, synthetic methods should be conducted at ambient temperature and pressure.
7. **Use of Renewable Feedstocks:** A raw material or feedstock should be renewable rather than depleting whenever technically and economically practicable.
8. **Reduce Derivatives:** Unnecessary derivatisation (use of blocking groups, protection/deprotection, temporary modification of physical/ chemical processes) should be minimised or avoided if possible, because such steps require additional reagents and can generate waste.
9. **Catalysis:** Catalytic reagents (as selective as possible) are superior to stoichiometric reagents.
10. **Design for Degradation:** Chemical products should be designed so that at the end of their function they break down into innocuous degradation products and do not persist in the environment.

11. **Real-time Analysis for Pollution Prevention:** Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. **Inherent Safer Chemistry for Accident Prevention:** Substances and the form of a substance used in a chemical process should be chosen to minimise the potential for chemical accidents, including releases, explosion, and fires.

The Future of Green Chemistry

There is no doubt that the emerging area of Green Chemistry has identified scientific principles, approaches, and methodologies that have demonstrated the most positive aspects of chemistry. While the successes of Green Chemistry thus far seem quite large in terms of quantitative benefit to human, health and the environment, they are merely the tip of the iceberg when compared to the potential. To reach this full potential, greater awareness, adoption, and development of Green Chemistry practices are necessary. [2]

Sustainable economic development depends on the chemical industry to produce a vast array of chemical products. Thus, in the future, the main sustainability target with regard to chemicals will be to apply inherently safe chemicals, which are unlikely to pose a risk to human health and environment even without specific exposure control measures due to the lack of hazardous properties. This should be particularly valid for open applications. In contrast, very hazardous chemicals should be authorised and used only in closed systems or in installation where releases are negligible, thus posing no risk for human and environment.[3]

Green Chemistry is a dynamic match of scientific, economic and social interests that leads to a future where chemistry is viewed as fundamental to protecting the environment. However, the success of Green Chemistry, will depend directly on the training and dedication of a new generation of Chemists—the students of today.

World Wide Web Resources [5]

Some websites that may be useful for those trying to incorporate Green Chemistry into their teaching are given below:

1. http://www.acs.org/education/greechem/
2.http://www.lanl.gov/greenchemistry/
3. http://www.epa.gov/greenchemistry/
4. http://www.rsc.orq/is/iournals/current/green/greenpub.htm.
5. http://www.rsc.org/is/journals/current/green/GCOO2001.htm
6. http://www.chemsoc.org/networks/gcn/.

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GCl Website: http://www.lanl.gov/greenchemistry/.Listserver: gci@lanl.gov

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Hearing – A Physical Phenomenon

VANITHA DANIEL
Lecturer
DIET, Kurukkathi
Nagapattanam, Tamilnadu
V.S. SURESH KUMAR
Lecturer in Physics (S.G.)
T.B.M.L. College
Porayar 609 307
Tamilnadu

EVEN IN THE quietest country side, there are still sounds, such as wind, singing birds and buzzing insects. Sound waves, a physical phenomenon, are sure to occur when a falling tree hits the ground. The human auditory system enables us to hear not only the sound produced by a falling tree, but also the birds singing in the trees and the wind blowing through their leaves. Our auditory systems are amazingly well adapted for detecting and interpreting an enormous variety of information.

Properties of Sound Waves

Sound waves are characterised by their amplitude, their wave length and their purity. These physical properties affect mainly the perceived qualities and sound like its loudness, pitch and timbre. Varying wavelengths of sound are described in terms of their frequency, which is measured in cycles per second or hertz (Hz).

Frequency

The frequency of a sound is the number of compressions per second, measured in hertz (Hz-cycles per second). Pitch is a perception closely related to frequency. As a rule, the higher the frequency of a sound, the higher is its pitch. The maximum displacement of the wave corresponds to amplitude and the number of waves per second corresponds to frequency (Fig.1).

Higher frequencies are perceived as having higher ptich. Humans can hear sounds ranging in frequency from a low of 20 Hz upto a high of about 20,000 Hz. Sounds of either end of this range are harder to hear. At the other extremes, bats and porpoises can hear frequencies well above 20,000 Hz. Low frequency sounds under 10 Hz are audible to homing pigeons.

Amplitude

In general, the greater the amplitude of sound waves, the louder the sound perceived (Fig. 1). The amplitude is measured in decibels (dB). Even brief exposure to sounds over 120 decibels can be painful and affects auditory system.

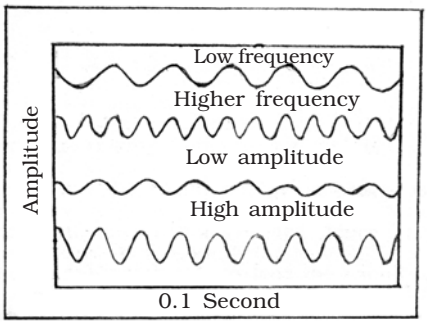

Fig. 1: Four Sound Waves of different frequencies and amplitude

The following table gives the relative intensities of a few sounds. The threshold intensity is taken as zero decibel.

Soft music	–	40 decibels
Telephone	–	60-70 decibels
Busy traffic	–	70-85 decibels
Alarm clock	–	80 decibels
Jet aircraft	–	115-120 decibels

According to WHO Noise affects health and prolonged exposure to sound above 140 decibels may produce insanity.

Perception of high frequency decreses with age. Preschool children are better than adults at hearing frequencies of 2,000 Hz and above (B.A. Schneider Trehub, Morron giello & Thorpe 1986). For middle aged adults, the upper limit for hearing decreases by about 80 Hz every six months (Von Bekery 1987). The upper limit drops even faster for those exposed to loud noises.

Loudness

The loudness of a note depends upon the intensity of sound or the rate of flow of energy to the ear. But it is not proportional to it since the sensitiveness of the ear varies with the pitch. Near the middle of the audible range of frequencies, the ear is mot sensitive to changes of intensity which it interprets as loudness.

Sensory Processing in the Ear

Our ears are specially designed to detect sound waves, turn them into nerve signals and send these nerve signals to the brain which analyses them and identifies the sound. Sound waves are periodic compression of air, water or other media. When a source emits sound it basically sets up vibration in the surrounding medium. The vibrating source sets up tiny disturbances in the surrounding medium. These disturbances in air cause rise and fall of air pressure relative to the normal ambient pressure. As the sound waves travel through the medium, the sound energy is passed on by the air molecules via vibration. The sound waves reach the listener from the source in this manner. The sound wave simply impinges upon a funnel (the pinna) in the human ear, which acts to feed the sound wave down a natural tube (the ear canal) to a terminating membrane (Jympanic membrane) to make it vibrate in response to the sound pressure variation and hence 'pass on' the sound energy via mechanical vibration. The sound wave is enhanced on arrival at the ear drum. This is a result of head baffle and ear cancel resonance. Figure 2 shows different regions of the pasilar

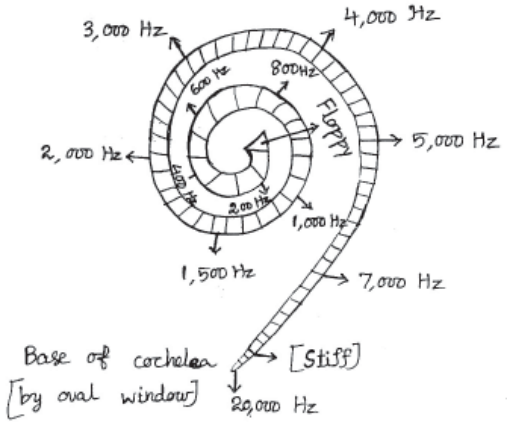

Fig. 2: The Basilar Membrane of the Human Cochlea

membrane of the ear that are sensitive to different range of frequencies.

If a person is to perceive a stimulus, it will be necessary to translate the molecular sound energy to fluid vibratory energy in the cochlea, which will in turn produce the electrical potentials of the auditory nerve fibres. This can be achieved effectively in human by means of conducive pathway of the ear, which facilitates the efficient transfer of acoustic vibratory energy into fluid vibratory energy, with the resultant generation of electrical potentials in the auditory nerve (Fig. 3).

of sound energy transfer from tympanic membrane to stapes foot plate being achieved via mechanical vibration of the ear ossicles. The sound pressure at the stapes foot plate is therefore enhanced by a factor of ~18 relative to that at the tympanum membrane.

The ossicles may be considered as a series of levers. Since the length of the manubrium and nech of the malleus is longer than the long process of the incus, a mechanical advantage of 1.3 results. Overall boost to sound pressure at the stapes foot plate is approximately a factor of 23 (i.e. 18 × 1.3).

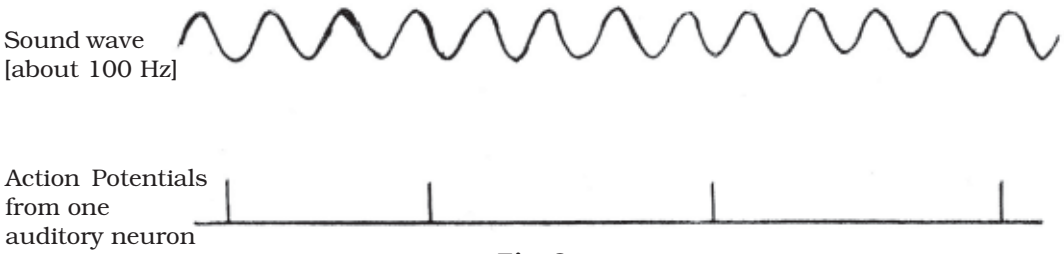

Fig. 3

Air molecules are very light, inelastic particles while the perilymph molecules are much denser and highly elastic. It is necessary to boost the incoming sound wave, so that an effective transfer of energy to the fluid medium is achieved. The sound pressure at the tympanic membrane is enhanced to that at the entrance to the pinna by the resonance effects of cochlea and ear canal. This sound pressure acts upon the tympanic membrane and causes vibration. Two-thirds of membrane area is involved in sound pressure transfer to the manubrium of the mallius — a passage

The inner ear consists largely of the cochlea a fluid filled coiled-tunnel that contains the receptors for hearing. The basilar membrane, which runs the entire length of the spiraled cochlea, holds the authority receptors called hair cells.

Vibrations that are transmitted to cochlea through the oval window by the foot plate of the stapes set up vibrations in the perilymph which surrounds the membranous labyrinth containing the end organs of hearing and balance. At last the vibration of the basilar membrane cause a pull or shearing force

on the hair cells attached to the tectorial membrane. This action transform the fluid vibratory energy into electrical impulses that stimulate the fibres of the acoustic nerve (eighth cranial nerve). These signals then travel along the acoustic nerve to the brain where they are translated into sound, whether it is the sound of rustling leaves or chirping birds or cars backfiring.

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Nanoscience and Nanotechnology: Perspectives and Overview

R. RAVICHANDRAN
Regional Institute of Education (NCERT)
Bhopal 462 013

P. SASIKALA
Makhanlal Chaturvedi National
University, 222 Zone-I, MP Nagar
Bhopal 462 011

NANOSCIENCE is fast becoming one of the major areas of science. Its appeal lies in the long-dreamt-of ability to investigate and manipulate matter at the level of individual atoms and molecules. And while it is scientific curiosity that is currently driving research forward in this area, there is the tempting thought that discoveries could play key role in a future world of nano-devices and nano-computers. Hence, it becomes very much essential on the part of the science teachers to get the science students exposed, enriched and motivated on this interdisciplinary field which is going to rule this knowledge society. Also efforts should be made to include this thrust area in school science curriculum appropriately, for a successful exploitation of this upcoming area.

Introduction to Nanotechnology

Nanotechnology is defined as fabrication of devices with atomic or molecular scale precision. Devices with minimum feature sizes less than 100 nanometres (nm) are considered to be products of nanotechnology. A nanometre is one billionth of a metre (10^{-9} m) and is the unit of length that is generally most appropriate for describing the size of single molecules. The nanoscale marks the nebulous boundary between the classical and quantum mechanical worlds; thus, realisation of nano-technology promises to bring revolutionary capabilities. Fabrication of nanomachines, nanoelectronics and other nanodevices will undoubtedly solve an enormous amount of the problems faced by mankind today.

Nanotechnology is currently in a very infantile stage. However, we now have the ability to organise matter on the atomic scale and there are already numerous products available as a direct result of our rapidly increasing ability to fabricate and characterise feature sizes less than 100 nm. Mirrors that don't fog, biomimetic paint with a contact angle near 180°, gene chips and fat soluble vitamins in aqueous beverages are some of the first manifestations of nanotechnology. However, immenant breakthroughs in computer science and medicine will be where the real potential of nanotechnology will first be achieved.

Nanoscience is an interdisciplinary field that seeks to bring about mature nanotechnology. Focusing on the nanoscale intersection of fields such as physics, biology, engineering, chemistry, computer science and more, nanoscience is rapidly expanding. Nanotechnology centres are popping up around the world as more funding is provided and nanotechnology market share increases. The rapid progress is apparent by the

increasing appearance of the prefix "nano" in scientific journals and the news. Thus, as we increase our ability to fabricate computer chips with smaller features and improve our ability to cure disease at the molecular level, nanotechnology is here.

A Brief History of Nanotechnology

The amount of space available to us for information storage (or other uses) is enormous. As first described in a lecture titled, 'There's Plenty of Room at the Bottom' in 1959 by Richard P. Feynman, there is nothing besides our clumsy size that keeps us from using this space. In his time, it was not possible for us to manipulate single atoms or molecules because they were far too small for our tools. Thus, his speech was completely theoretical and seemingly fantastic. He described how the laws of physics do not limit our ability to manipulate single atoms and molecules. Instead, it was our lack of the appropriate methods for doing so. However, he correctly predicted that the time would come in which atomically precise manipulation of matter would inevitably arrive.

Prof. Feynman described such atomic scale fabrication as a 'bottom-up' approach, as opposed to the 'top-down' approach that we are accustomed to. The current top-down method for manufacturing involves the construction of parts through methods such as cutting, carving and molding. Using these methods, we have been able to fabricate a remarkable variety of machinery and electronics devices. However, the sizes at which we can make these devices is severely limited by our ability to cut, carve and mold.

Bottom-up manufacturing, on the other hand, would provide components made of single molecules, which are held together by covalent forces that are far stronger than the forces that hold together macro-scale components. Furthermore, the amount of information that could be stored in devices built from the bottom-up would be enormous.

Since that initial preview of nanotechnology, we have developed several methods which prove that Prof. Feynman was correct in his prophesy. The most notable methods are 'scanning probe microscopy' and the corresponding advancements in 'supramolecular chemistry'. Scanning probe microscopy gives us the ability to position single atoms and/or molecules in the desired place exactly as Prof. Feynman had predicted. Although the limitations of traditional chemistry were criticised in Prof. Feynman's lecture due to its seemingly tedious and random nature, recent advancements have improved its potential uses for nanotechnology.

Why Make Nanotechnology?

One might ask, 'what exactly are the potential uses of nanotechnology?' In the limited number of years that nanotechnology has been considered possible, a plethora of answers to this question have been presented. Possible answers include quantum computers, long term life preservation and virtually everything in between. It seems that nanotechnology could potentially solve

just about any problem that we could think of; thus, a more interesting question is, 'what real problems will nanotechnology solve first?' As of now, it appears that the first revolutionary applications of nanotechnology will be in computer science and medicine. These two fields will most likely be affected first since they both call for molecular scale manipulation of matter in the near future.

Nanomaterials. Nanodevices and Applications of Nanomaterials

Nanomaterials are single-phase or multi-phase polycrystals with a typical crystal size of 1 to 100 nm in at least one dimension. Depending on the dimensions they can be classified into (a) nanoparticles; (b) layered or lamellar structures; (c) filamentary structures; and (d) bulk nanostructured materials. The properties of nanomaterials mainly depend on four features, namely (a) grain size and size distribution; (b) chemical composition; (c) presence of interfaces (grain boundaries, free surface); and (d) interactions between the constituent domains. Due to the large surface/ interface to volume ratio in nanophase materials, a wide variety of size-related effects can be introduced by controlling the size of the particles:

- The density of dislocation, interface to volume ratio and the grain size strongly influence the mechanical properties.
- Quantum confinement, i.e., quantisation of the energy levels of the electrons due to confined grain size, has applications in semiconductors, optoelectronics, and nonlinear optics. Nanoclusters, so-called quantum dots for example can be developed to emit and absorb a specific wavelength of light by changing the particle diameters.
- The large amount of surface atoms increases the activity for catalytical applications.
- The magnetic properties of nano-sized particles depend on the large surface to volume ratio. Unlike bulk materials consisting usually of multiple magnetic domains, several small ferromagnetic particles can form only a single magnetic domain, giving rise to superparamagnetism. This behaviour opens the possibility for applications in information storage.

Nanodevices may be defined as structurally organised and functionally integrated chemical systems in the dimension of nanometres. The components may be photo-, electro-, iono-, magneto-, thermo-, mechano-, or chemoactive, depending on whether they handle photons, electrons, or ions, respond to magnetic fields or to heat, undergo changes in mechanical properties, or perform a chemical reaction.

Areas of application that can be foreseen to benefit from the small size and organisation of nanoscale objects include quantum electronics, nonlinear optics, photonics, chemoselective sensing, and information storage and processing, adsorbents, catalysis, solar cells,

magnetic recording devices, superplastic ceramics, superhard metals, metastable alloys.

Semiconductor Fabrication

Moore's law, optical lithography and the search for alternatives

Computer chips (and the silicon based transistors within them) are rapidly shrinking according to a predictable formula (by a factor of 4 every 3 years – Moore's Law). According to the Semiconductor Industry Association's extrapolation of formulas such as this one (SIA road map) it is expected that the sizes of circuits within our chips will reach the size of only a few atoms in about 20 years.

Since almost all of our modern computers are made from silicon 'semiconductor' transistors patterned and carved by light (photolithography), the shrinking of circuits predicted by the SIA may not be the most economical method for the future. An enormous amount of money has been invested in the semiconductor industry in order to consistently shrink and improve our semiconductor electronics. Smaller circuits require less energy, operate more quickly and, of course, take up less space. Thus, Moore's law has been adhered to since computers first became commercially available. However, this simple shrinking of components can not continue for much longer.

As transistors such as the Metal-Oxide Semiconductor Field Effect Transistor (MOSFET - one of the primary components used in integrated circuits) is made smaller, both its properties and manufacturing expense change with the scale. Currently, Ultraviolet light is used to create the silicon circuits with a lateral resolution around 200 nm (the wavelength of ultraviolet light). As the circuits shrink below 100 nm new fabrication methods must be created, resulting in increasing costs. Furthermore, once the circuit size reaches only a few nanometres, quantum effects such as tunneling begin to become important, which drastically changes the ability for the computers to function normally. Thus, novel methods for computer chip fabrication have been and are being intensely sought by microchip manufacturers.

Molecular and Quantum Computing

Alternative architectures for nanocomputing

In addition to single electron transistors, two promising alternatives to traditional computers are molecular computing and quantum computing. These two methods are intimately related, yet deal with information on two different levels. Much progress has been made in these areas during the last few years and both have been shown to be feasible replacements for semiconductor chips.

Quantum computing seeks to write, process and read information on the quantum level. It is at the nanoscale that quantum mechanical effects such as (the wave particle duality) begin to become apparent. Numerous scientists are seeking ways to store information within the 'quantum mechanical' realm. This is not a simple task because of the delicate nature of quantum mechanical

systems. However, since the laws of quantum mechanics involves unintuitive principles such as superposition and entanglement, a quantum computer would be able to violate some rules that limit our classical computers. For instance, taking advantage of superposition would mean that a quantum bit of information, termed a 'qubit' would be able to be used in several computations at the same time. Taking advantage of entanglement would mean that the information could be processed over 'long distances' without the classical requirement of wires.

Molecular computation is another method complimentary to quantum computing that seeks to write, process and read information within single molecules. One molecule that has proved most promising for molecular computation is Deoxyribonucleic acid (DNA). DNA is a long polymer made of 4 different nucleotides that can be represented by the letters A, T, C and G. The order or sequence of these nucleotides within DNA provides the information for making protein, the main components of the molecular scale machinery used by living organisms to carry out life sustaining functions.

Mathematicians have figured out numerous ways to use DNA as the various proteins that come with it to carry out numerical computations that are notoriously difficult for silicon computers, namely 'NP-complete' problems. The advantage that molecular computing using DNA has over conventional computing is that it is massively parallel. This means that each DNA molecule can function as a single processor, which greatly improves the speed of computation for complex problems.

Medical Applications

Molecular medicine, bioinformatics and biomolecular nanotechnology are rapidly increasing our ability to heal and stay healthy

The other field in which molecular scale manipulation of matter is receiving abundant attention is medicine. Since all living organisms are composed of molecules, molecular biology has become the primary focus of biotechnology. Countless diseases have been cured by our ability to synthesise small molecules commonly known as 'drugs' that interact with the protein molecules that make up the molecular machinery that keeps us alive. Our understanding of how proteins interact with DNA, phospholipids and other biological molecules is what allows such progress.

Living systems are able to live because of the vast amount of highly ordered molecular machinery from which they are built. The central dogma of molecular biology states that the information required to build a living cell or organism is stored in the DNA (which was described above for its use in molecular computation). This information is transferred from "M the DNA to the proteins by the processes called 'transcription' and 'translation'. These processes are all executed by various biomolecular components, mostly protein and nucleic acids.

Molecular biology is a field in which the study of these interactions has led to the discovery of numerous pharmaceuticals that have been enormously effective in curing disease. Understanding of molecular mechanisms, including substrate recognition, energy expenditure, electron transport, membrane activity and much more have greatly improved our medical technology.

So, what does this have to do with nanotechnology? First of all it shows the abilities of molecular scale machinery. Since the goal of nanotechnology is molecular and atomic precision, nanotechnology has much (if not everything) to learn from nature. Copying, borrowing and learning tricks from nature is one of the primary techniques used by nanotechnology and has been termed 'biomimetics'. Secondly, our ability to design synthetic, semi-synthetic and natural molecular machinery gives us an enormous potential for curing disease and preserving life. An extensive textbook titled 'Nanomedicine' has been written and does an excellent job of summarising how nanotechnology is changing medicine.

Molecular Simulation

Computer models of atoms, molecules and nanostructures provide the theory behind nanoscience

Finally, a branch of computer science that is allowing rapid progress to be made in nanotechnology is the computer simulation of molecular scale events. Molecular simulation is able to provide and predict data about molecular systems that would normally require enormous effort to obtain physically. By organising virtual atoms in a molecular simulation environment, one can effectively model nanoscale systems. Deepak Srivastava, one of the world's leading experts in molecular simulation and computational nanotechnology, has described the situation with the following quote, *Theory, modeling and simulations have provided and will continue to provide insights into what to expect next and verification/explanation* of *what has been done or observed experimentally. For nanoscale systems, simulations and theory in fact have provided novel properties that has led to new designs, materials and systems for nanotechnology applications. For example carbon nanotubes applications in molecular electronics or computers were predicted first by theory and simulations, the experiments are now following up to fabricate and conceptualise new devices based on those simulations.*

Current limitations of molecular simulation techniques are the molecular simulation algorithm and computation time for complex systems. Force field algorithms are currently quite efficient and are often used today. However, such models neglect electronic properties of the system. In order to calculate electron density, quantum mechanical models are required. However, as the number of atoms and electrons is increased, the computational complexity of the model quickly reaches the limits of our most modern supercomputers. Thus, as the computational abilities of our computers are improved (often with help from

nanoscience), increasingly complex systems will be within the reach of molecular simulation.

The Future

Nanotechnology has arrived, but it has yet to realise its full potential

Our computers are quite fast and small, but no revolutionary breakthrough in computing has happened since the transistor was invented. The human genome project has reached completion, yet limits in our ability to cure disease on a molecular basis remain. While it is often difficult to predict the future, some things seem inevitable. Just as a ball thrown into the air can be expected to fall to the ground, so can we expect our technology to reach the molecular scale. We must keep a very close pace with this new technology to harvest the best potentials at the right time or else we will perish.

Useful links on the NET

www.nano.ku.dk/research/nanochemistry/
www.nanoindustries.com
www.cordis.lu/nanotechnology/
www.nanonet.de
www.ieee.org/portal/index
www.nanotechweb.org
http://home.pusan.ac.kr/~nanobio//
http://nano.gov/
www.nanoapex. com
www.nd.edu/~ndnano/index.html
www.nanobio.com
www.nsti.org/
www.nanobionet.de/
www.nanoword.net/pages/quiz.htm
www.mitre.org/tech/nanotech/
www.nanoword.net/pages/busquiz.ht

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An Investigation into the Learning Difficulties Experienced by Indian School Children In Learning Division Algorithm of Simple Fractions

TAPAN KUMAR MAITI
Assistant Teacher
Hetia High School (H. S.)
JAYANTA KUMAR METE
Reader, Department of Education
University of Kalyani
Nadia, West Bengal 741 235

THE ONLY division algorithm for simple fractions which is being taught to the school children is the reciprocal algorithm. Apparently it is very simple. But, taught mechanically, it gives rise to many learning difficulties, which the present investigation intends to highlight for the benefit of students, teachers and method masters.

Introduction

After the introduction of cheap hand-held calculating machines, use of decimal fractions in daily life has become very convenient. The teaching-learning of decimal fractions has also undergone a sea change.

But matters have not been so much fortunate in case of public use or teaching-learning of simple fractions (also called "common" or "vulgar" fractions), though they have been as useful as before. There is no mechanical device to facilitate the use of such fractions. The teaching-learning of the algorithms of simple fractions has remained the same for decades.

Under these circumstances, the only ways to ameliorate the teaching-learning of simple fractions are to select the methods of operation for them most judiciously, and to follow up their teaching-learning with diagnostic programmes and remedial measures.

The Only Division Algorithm for Simple Fractions taught in Schools

Now there is one division algorithm for simple fractions that is used in the schools for teaching the school children. It is the reciprocal algorithm. Its rule is as follows:

To divide a number by a fraction multiply the number by the reciprocal of the fraction.

(The reciprocal of a fraction is the fraction formed by interchanging the numerator and denominator; for example, the reciprocal of $\frac{c}{d}$ is $\frac{d}{c}$).

Thus, in this method:

$$\frac{a}{b} \div \frac{c}{d} = \frac{a}{b} \times \frac{d}{c}$$

The rationale of the method is as follows.

$$\frac{a}{b}\,\frac{c}{d} \quad \frac{a}{b}\,\frac{d}{c} \quad \frac{c}{d}\,\frac{d}{c} \quad \frac{a}{b}\,\frac{d}{c} \quad 1 \quad \frac{a}{b}\,\frac{d}{c}.$$

So we see that, in this method, the divisor is reduced to unity by multiplying it by its reciprocal fraction. To keep

balance, the dividend is also multiplied by reciprocal of the divisor.

The major criticism of this method is that the teachers often forget to tell the students the mystery behind the inversion of the divisor, and then its use as the multiplier of the dividend to get the quotient.

Previous Researches on Simple Fractions

From a study of recent researches on simple fractions, it was found that the algorithms of simple fractions had not drawn the attention of investigators during the last 25 years. In 1930, Brueckner administered his 'Diagnostic Test in Fractions' to 400 sixth grade British pupils and made an analysis of the most frequent types of errors [Blair 1962, 231-234]. In 1979 Smith experimentally compared two methods (techniques) of division of fractions, namely, 'The common denominator method' and the 'Reciprocal Method' (also called the 'Method of Inversion') on their related gain in pupil achievement. The reciprocal was found by him superior to the common denominator method and is significantly increasing pupils' achievement in division of simple fractions [vide C. A. Smith, 'Effect of a Meaningful treatment for Division of Fractions a Comparative Study' (unpublished Doctoral Dissertation, the University of Texas at Austin, 1979). In India, in 1980 A. Bhattacharya conducted a doctoral study 'to diagnose and prevent the learning disabilities of Indian primary school students in simple and decimal fractions' [unpublished Doctoral Dissertation, University of Calcutta, 1980].

Need of Diagnostic Programmes

Faulty teaching-learning of the basic mathematical skills may lead to development of learning difficulties in a student. Uncorrected for long, the learning difficulties may develop into permanent-learning disabilities which may impede the learning of mathematics and career of the concerned student.

Hence diagnostic testing after the testing-learning of basic mathematical skills should be an integral part of a school programme. The data can help a sincere teacher to help the concerned students individually to ameliorate their learning. It would also help the teacher to formulate his/her teaching strategies so that the learning difficulties may not occur in his/her students in future

Need of the Study

Thus, the only work, investigators of present study, known to in the last 25 years that had considered Indian students' learning difficulties in simple fractions, was that of A. Bhattacharya (1980). It is unfortunate that the investigator paid little attention to division of simple fractions, probably thinking that it was only a modified version of fraction multiplication, which the 'Reciprocal' or 'Inversion' Method of division of fractions appears to be to many.

But experts like Brueckner [Ibid], Siddons [Godfrey and Siddons 1957, 123-124], Mueller [Mueller 1964,251-252], Adams, Ellis and Beeson [Adams, Ellis,

and Beeson 1977, 138] and many others have pointed out that, though apparently the reciprocal algorithm for division of fractions is very easy to use and practise, it is the major source of learning difficulties faced by the school students in doing division of fractions sums in arithmetic.

This is why the investigators took upon themselves the task of finding out, for the first time ever, the learning difficulties of the Indian pupils in solving division sums by the application of the reciprocal algorithm of simple fractions.

The Diagnostic Test used in the Study

"Brueckner Diagnostic Test in Division of Fractions" was published by the Educational Test Bureau, Minneapolis, Minnesota in 1930, 1943. The Test (vide Table) attempts to determine in a very thorough manner what mistakes pupils make and why they make them. It contains 40 types of division sums. A diagnostic tabulation sheet provided for it assists the teacher in interpreting the data and in outlining suitable remedial work. It had been used in the study to analyse students' difficulties in using the reciprocal method of division of fractions (vide Table).

Purpose of the Study

One of the investigators of the present study is a practising school teacher, the other a methods master. Both wanted to know the learning difficulties likely to be developed by Indian school students in the teaching-learning of the division algorithm for simple fractions. But they found no such recent study conducted on Indian school students. The knowledge was important for both of them, because the school teacher had to chalk out his teaching strategies in order to prevent development of learning difficulties amongst his pupils. And the methods teacher had to instruct the trainees in this matter.

Selection of the Experimental School

The investigators were in favour of a school in between low-achieving and high-achieving schools in which the students had been taught division of fractions in a rather casual and mechanical manner. Such a school usually contains all types of students. They found a school in the Bankura District which fulfilled all these requirements, and, besides, it was a large school, with near about 200 students in Class VI. It was selected as the experimental school, as its students were expected to show all learning disabilities arising out of faulty learning-teaching of division of fractions.

The other details about the experimental school are as follows:
Type of school: Higher Secondary with Arts and Commerce streams.
Number of students (average of last three years) : 1400 students.
Nature of location : Rural.
General academic qualifications of guardians: Very few are graduates or have higher qualifications.

The Sample

The sample for the study consisted of 101 students of Class VI selected randomly from 185 students of the class. They had

been taught the reciprocal method of division of fractions "by rote", by being made to use the method only mechanically, without having any explanation of the inversion of the divisor and then its use as the multiplier. Actually it was this ignorance of the students for which the investigators had selected their class, as they were likely to display all possible learning errors for Indian students who are victims of faulty teaching of the reciprocal method.

Of the 101 students, 45 were boys and 56 girls. Their average age was 12 years. As the IQs of the students were unavoidable, their average score in the last Half yearly examination of 281 marks and their average score in the last Arithmetic Test in the last Half yearly examination of 28 marks were obtained instead, as the correlation between scholastic aptitude and academic achievement is very high.

Administration of the Diagnostic Test

The test was administered on the subjects on 23.10.02 (Wednesday) in two sittings. The first sitting was held from 1.10 to 1.50 p.m., and the second, after the tiffin recess, from 2.20 to 2.55 p.m. One of the investigators supervised the testings.

Results

The following Table presents the obtained data grouped under possible categories of learning difficulties. The analysis in the Table is based entirely upon an examination of the pupils' answer sheets after they had been tested in a group. Consequently, the cause of some of the errors which were found could not be ascertained. This is shown in 2(c) and 10 of the Table under the caption "unknown". Nonetheless, the analysis would provide the teacher with a list of the major mistakes pupils make in dealing with problems on fractions. Individual diagnosis would reveal the unknown sources of error.

Findings of the Study

Following were the findings of the diagnostic study:

1. 31.70 per cent (that is, approximately one third) of all mistakes in division of fractions were due to the student's negligence to invert the divisor before performing the process of multiplication.
2. 24.70 per cent of all mistakes in division of fractions were due to the student's lack of comprehension of the process involved.

These support Mueller's observation that the "why" behind the reciprocal method is not widely or easily understood which accounts for the computational blunders [Mueller 1964, 251]. Here the misunderstanding reached the peak [(1) + (2) make up for 56.40 per cent of total errors made by the pupils] because the students had not been explained the logic behind the reciprocal method and were asked to use it mechanically without asking for the "why" of it. That is why the students inverted the dividend in place of the divisor (9.82 per cent of total errors were due to it), or inverted both dividend and divisor (13.82 per cent of total errors were due to it), so that "inverting" the wrong term accounted for

Table 1: Analysis of Difficulties in Division of Fractions

Different Types of Errors		Number of Errors	Per-centage
1. **Wrong operation: Multiplication:** $\left(1\frac{3}{8} \div 1\frac{2}{3}\right) = \frac{11}{8} \times \frac{5}{3} = \frac{55}{24} = 2\frac{7}{24}$		565	31.70
2. **Computation Errors**			
(a) Division: $3\frac{3}{8} \div 1\frac{3}{4} = \frac{27}{8} \times \frac{4}{7} = \frac{27}{14} = \frac{13}{14}$	3		
(b) Multiplication: $1\frac{1}{8} \div 3\frac{1}{2} = \frac{6}{5} \times \frac{2}{7} = \frac{12}{30} = \text{or } \frac{2}{5}$	54		
(c) Unknown: $3\frac{1}{3} \div 1\frac{3}{4} = \frac{10}{3} \times \frac{4}{7} = \frac{40}{21} = \text{or } 3\frac{1}{21}$	20		
		77	4.32
3. **Lack of Comprehension of process involved**			
(a) Inverts dividend: $1\frac{1}{5} \div 3\frac{1}{2} = \frac{5}{6} \times \frac{7}{2} = \frac{35}{12} = \text{or } 2\frac{11}{12}$	175		
(b) Inverts both dividend and divisor: $1\frac{3}{8} \div 1\frac{2}{3} = \frac{8}{11} \times \frac{3}{5} = \frac{24}{55}$	246		
(c) Adds denominators and multiplies numerators: $1\frac{3}{8} \div 1\frac{2}{3} = \frac{11}{8} \times \frac{3}{5} = \frac{33}{13} \text{ or } 2\frac{7}{13}$	1		
(d) Adds numerators and multiplies denominators: $1\frac{1}{5} \div 3\frac{1}{2} = \frac{6}{5} \times \frac{2}{7} = \frac{8}{35}$	2		
(e) Disregards denominator in quotient: $3\frac{1}{8} \div 1\frac{1}{4} = \frac{25}{8} \times \frac{4}{5} = 5$	5		
(f) Disregards numerator: $\frac{1}{9} \div \frac{1}{3} = \frac{1}{9} \times \frac{3}{1} = 3$	11		
		440	24.70

4. **Difficulty in Reducing Fractions to the lowest terms** (a) Does not reduce: $1\frac{1}{3} \div 3\frac{1}{3} = \frac{4}{3} \times \frac{3}{10} = \frac{4}{10}$ (b) Divides denominator by numerator: $1\frac{3}{8} \div 1\frac{2}{3} = \frac{11}{8} \times \frac{3}{5} = \frac{33}{40} = 1\frac{7}{33}$	57 –	57	3.20
5. **Difficulty in changing mixed numbers to improper fractions:** $3\frac{1}{3} \div 1\frac{3}{4} = \frac{10}{3} \times \frac{4}{12} = \frac{20}{18} = 1\frac{1}{9}$		84	4.71
6. **Omitted**		10	0.57
7. **Failure to reduce improper fractions to mixed numbers:** $3\frac{1}{8} \div 1\frac{1}{4} = \frac{25}{8} \times \frac{4}{5} = \frac{5}{2}$		201	11.27
8. **Errors in copying:** $1\frac{1}{4} \div \frac{1}{3} = \frac{5}{2} \times \frac{3}{1} = \frac{15}{2}$ or $7\frac{1}{2}$		174	9.76
9. **Cancellation Difficulties:** (a) Cancels within the denominators: $\frac{5}{6} \div 4 = \frac{5}{6} \times \frac{1}{4} = \frac{5}{6}$ (b) Cancels within the numerators: $1\frac{1}{5} \div 3\frac{1}{2} = \frac{6}{5} \times \frac{3}{7} = \frac{3}{35}$	3 9		
10. **Unknown:** $1\frac{1}{3} \div 3\frac{1}{3} = \frac{1}{5}$		12	0.67
		162	9.10
		1782	100.00

Notes: $\frac{565}{1782} \times 100 \times 31.70$

23.64 per cent of total errors committed. As stated, non-inversion accounted for 24.70 per cent errors. The similarity of the findings of the two diagnostic testings held 75 years apart upon children of two different nations cannot escape our notice.

One of the testings was Brueckner's held in 1930 upon 400 British school children. The other was by the investigators' held in 2002 upon 101 Indian school children of the same grade and age group. In both the groups of children, nearly one-third missed to invert the divisor before using it as the multiplier of the dividend. But there were also dissimilarities in findings. Whereas 13.8 per cent of the British pupils committed computation errors, it was only 4.32 per cent in case of the Indian pupils, on the other hand, while 12.1 per cent of the British pupils committed errors for "Lack of Comprehension of the process involved", the figure was double (24.70 per cent) for the Indian pupils.

Suggestions for Prevention of Learning Difficulties

Godfrey and Siddons think that the rule of the reciprocal method of division of fractions, viz., "Turn the divisor upside down and multiply by that" is quite unnecessary and certainly dangerous for the beginners. Instead of beginning with the method, Siddons has suggested the following method to start with [Godfrey and Siddons 1957, 123-124]. "If the children are clear that $5 \div 8 = \frac{5}{8}$, it is natural to assume that $\frac{3}{4} \div \frac{2}{5} = \frac{3/4}{2/5}$

"This fraction has four "stories" and we only want two. Obviously we should improve matters by multiplying top and bottom by 4 and also 5.

$$\therefore \frac{3}{4} \div \frac{2}{5} = \frac{3/4}{2/5} = \frac{3/4 \times 4 \times 5}{2/5 \times 4 \times 5} = \frac{3 \times 5}{2 \times 4} = \frac{15}{8} = 1\frac{7}{8}.$$

Siddons expects that (see above) many pupils will discover the "reciprocal method" herefrom.

Siddons has also pointed out two other benefits (other than preventing the development of learning difficulties in the division of fractions) of the treatment suggested by him [Ibid, 124] :

1. "In the treatment I have suggested; the whole argument is made to hang on the one rule, 'the golden rule about fractions' —

   'The value of a fraction is unaltered by multiplying (or dividing) numerator and denominator by the same number.'
2. Exactly the same principles are used when dealing with fractions in algebra."

The investigators however are of the opinion that, as the reciprocal method is the easiest division algorithm of fractions, it will be desirable if it is taught and learned with proper understanding of its logic. So the beginner will work out the whole process as the following worked out problem, and will themselves abbreviate the method.

Example 1 $\frac{2}{3} \div \frac{4}{15}$. The reciprocal of $\frac{4}{15}$ is $\frac{15}{4}$. Multiplied by it, the divisor will

be reduced to unity. But to keep balance, the dividend will also be multiplied by $\frac{15}{4}$.

$$\therefore \frac{2}{3} \div \frac{4}{15} = \left(\frac{2}{3} \times \frac{15}{4}\right) \div \left(\frac{4}{15} \times \frac{15}{4}\right) = \left(\frac{2}{3} \times \frac{15}{4}\right) \div 1 = \frac{2}{3} \times \frac{15}{4}.$$

Example 2

$$1\frac{3}{5} \div 3\frac{1}{5} = \frac{8}{5} \div \frac{16}{5} = \left(\frac{8}{5} \times \frac{5}{16}\right) \div \left(\frac{16}{5} \times \frac{5}{16}\right) = \left(\frac{8}{5} \times \frac{5}{16}\right) \div 1 = \frac{8}{5} \times \frac{5}{16}.$$

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On Composition of Natural Numbers

M.N. Bapat
Regional Institute of Education
Mysore

R.K. Sonwane
Department of Mathematics
Govt. P.G. College, Balaghat
(Earlier Teacher Research Fellow, Dr.
H.S. Gour Vishwavidyalaya
Sagar 470 003)

Nature manifests itself through a variety of things live, dead or in fossil forms and that too in several numbers. Here by number we mean "that handy device which helps us to judge and feel the extent of its manifestation" .

The number has been the building block of mathematics. The history of counting things by a set of numbers is quite old. Adding a least integer count 'one' to its preceding number has lead to the formation of the successive integral numbers. Basically a number not only gives an idea about the size of a physical quantity but also presents by what combination it can be arrived at.

If we critically observe the composition (structure) of a number we might take a step forward in understanding the nature's intricacies. The questions like: Why there are a certain number of leaves, spots, bushes or veins in plants? Why there are a certain number of arms, legs, etc. to an animal? What is the rationale for the number of branches to a natural species? And so on.

Here we will discuss how a number > 1 is built up? What combinations or components can a number be arrived at? What is unique about the components of a number? What is the consequence of some of the unique components? And may be similar other questions.

Number as a Sum of Numbers

Let us first consider a few natural numbers.

If we look at these combinations carefully we see that as we move to

1*	=	1					
2	=	1 + 1					
3*	=	1+2					
4	=	1+1+2	or	2+2			
5	=	1+2+2	or	2+3	or	1+1+3	etc .....
6*	=	1+2+3	or	2+4	or	3+3	etc .....
7	=	2+3+4	or	3+4	or	2+5	etc .....
8	=	1+3+4	or	3+5	or	2+6	etc .....
9	=	1+3+5	or	2+7	or	4+5	etc .....
10*	=	1 + 2 + 3 + 4	or	3+7	or	4+6	etc.....

higher numbers we have several combinations of its formation. Now observe the numbers that are underlined. It is clear that these numbers can be formed by combination of independent numbers.

1*	=	1				
3*	=	1+2				
5*	=	1+2+2	or	2+3		
6*	=	1+2+3				
7	=	2+3+4	or	3+4	or	2+5
8	=	1+3+4	or	3+5	or	2+6
10*	=	1+2+3+4				

Further it is interesting to note that the starred (*) numbers are special in that they can also be formed by successive integers. If one asks a question like: What is the probability of formation of a number? Naturally the answer would be: it is proportional to the number of ways it can be obtained. Hence if we want to correlate these numbers to characterise a nature's manifestation we can expect that the probabilities of occurrence of the different species must be as per their numeric abundance. Does it happen? Let us examine.

According to simple mathematics the starred number N (i.e. N*) can be obtained as a sum of natural numbers up to a number n. As it is related through

$N^* = (n^12)\ (1 + n)$

Clearly the numbers span over the interval 1 to n.

Then if we encounter n varieties their disposition can be N fold.

Number as a Partition of Numbers

Let us now examine a few successive natural numbers formed by the combination of two numbers only.

2	=	1 + 1
3	=	1+2
4	=	1 + 3, 2 + 2
5	=	1 + 4, 2 + 3
6	=	1 + 5, 2 + 4, 3 + 3
7	=	1 + 6, 2 + 5, 3 + 4

so on

We can notice that the partition of number into two non-repetitive numbers can be obtained in (n/2) — 1 ways if n is even and (n-l)/2 ways if n is odd.

However, according to the theory of probability more equitable distribution among these would generally prevail in nature.

Now let us resolve the numbers into three components as

3	=	1+1+1
4	=	1+1+2
5	=	1 + 1 + 3, 1 + 2 + 2
6	=	1 + 2 + 3, 2 + 2 + 2
7	=	1 + 2 + 4, 2 + 2 + 3
8	=	1 + 2 + 5, 1 + 3 + 4

so on.

We find that there are several ways of doing so. But a partition into non-repetitive components is unique. It is well established and also we have shown in the theory of magic squares that it is the non-repetitive numbers that form a magic sequence. Then should we suggest that structures of many natural systems could be understood on the basis of non-repetitive components? Let us see what can be the basis for it.

Theoretically a partition for a decimal number system can be obtained from the expression

$$(X^1 + X^2 + X^3 + ... + X^9)^n$$

where n represents the number of partitions intended and powers of x represents the number to be partitioned into n components. The numbers of ways in which we get the desired power are the proper partitions. Thus if we want to partition 15 in 3 components then the power 15 of x is to be got from the equation

$$(X^1 + X^2 + X^3 + ... + X^9)^3$$

which is obtained as

X^{1+5+9}, X^{1+6+8}, X^{1+7+7}, X^{2+4+9}, X^{2+5+8}, X^{3+3+9}, X^{3+4+8}, X^{4+2+9}, X^{4+3+8}, X^{4+4+7}, X^{4+5+6}, X^{5+5+5}, etc.

If we identify among these partitions the partitions with non-repetitive numbers we see that only 8 partitions are unique. Incidentally as we have indicated these are the combinations that occur when we want to form a magic square.

Nature is scrupulously selective. It selects out probably unique combinations of the numbers in forming its variegated design for its animal and plant kingdom. Man is also taking advantage of the nature's selective nature in his endeavours for his developmental activities.

One may claim that if the theories are properly coordinated we can understand why certain numbers are preferred over the others in certain species of nature's creation.

With the advances in science, it has been claimed that a binary or hexadecimal system is to be preferred over the decimal number system. Let progress choose its own way but it may be remembered that by choosing a certain counting method the nature's unique manifestation is not going to alter.

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Science News

India to explore the moon

India has announced that it plans to explore the Moon and will send an unmanned probe there by 2008. The Indian Space Research Organisation (ISRO) calls the first Moon Flight Project *Chandrayan Pratham,* which has been translated as *First Journey to the Moon* or *Moonshot One.* The Chandrayan-1 weighing nearly 525 kg would be launched in 2007 or 2008 from one of India's own Polar Satellite Launch Vehicle (PSLV) space rockets. At first, the spacecraft would circle Earth in a Geosynchronous Transfer Orbit (GTO). From there, it would fly on out into a polar orbit of the Moon some 96 km above the lunar surface. The Chandrayan-1 mission would carry X-ray and gamma-ray spectrometers and would send back data that scientists on Earth would use to produce a high-resolution digital map of the lunar surface. The project's main objectives are high-resolution photography of the lunar surface using remote-sensing instruments sensitive to visible light, near-infrared light, and low-energy and high-energy X-rays. Space aboard the satellite also will be available for instruments from scientists in other countries.

The European Space Agency (ESA) has agreed to support India's plan to send a probe to the Moon by providing three science instruments for Chandrayan-1. They will be identical to those already in orbit around the Moon on ESA's Smart 1 spacecraft, which is surveying chemical elements on the lunar surface. The Indian lunar satellite also would carry with it a U.S. radar instrument designed to locate water and ice.

According to an ISRO press release, Chandrayan-1 is the first mission in "India's foray into a planetary exploration era in the coming decades". Chandrayan-1 will be the "forerunner of more ambitious planetary missions in the years to come, including landing robots on the Moon and visits by Indian spacecraft to other planets in the Solar System."

(*Source:* ISRO Press Release)

ISRO, NASA sign moon mission deal

Mr G Madhavan Nair, Chairman, ISRO, and Dr Michael Griffin, Administrator, National Aeronautics and Space Administration (NASA) of U.S.A. on May 9, 2006 signed Memoranda of Understanding (MoU) at ISRO Satellite Centre (ISAC), Bangalore. According to MoU two U.S. Scientific instruments would be included on board India's first mission to Moon, Chandrayan-1. These instruments are: Mini Synthetic Aperture Radar (Mini SAR) developed by Applied Physics Laboratory, Johns Hopkins University and funded by NASA and Moon Mineralogy Mapper (M^3), jointly built by Brown University and Jet Propulsion Laboratory (JPL) of NASA.

Chandrayan-1, scheduled during 2007-2008, is India's first unmanned scientific mission to moon. The main objective is the investigation of the

distribution of various minerals and chemical elements and high-resolution three-dimensional mapping of the entire lunar surface. ISRO's Polar Satellite Launch Vehicle (PSLV), will launch Chandrayan-1 into an earth orbit. Subsequently, the spacecraft's own propulsion system would be used to place it in a 100 km polar orbit around the moon.

The Indian payloads on board Chandrayan-1 include: a Terrain Mapping Camera (TMC), a Hyper Spectral Imager (HySI), a High-Energy X-ray spectrometer (HEX), a Lunar Laser Ranging Instrument (LLRI) and a Moon Impact Probe (MIP).

The two US instruments, Mini SAR and M^3, were selected on the basis of merit out of 16 firm proposals from all over the world received in response to ISRO's announcement of opportunity. The main objective of Mini SAR is to detect water in the permanently shadowed areas of lunar Polar Regions. The objective of M^3 is the characterisation and mapping of minerals on the lunar surface.

In addition to NASA instruments, three other instruments have already been selected by ISRO to be placed on board Chandrayan-1 from the European Space Agency. These are — Imaging X-Ray Spectrometer (CIXS) from Rutherford Appleton Laboratory, U.K., developed with contribution from ISRO Satellite Centre; Near Infra-Red Spectrometer (SIR-2) from Max Planck Institute, Germany; and Sub keV Atom Reflecting Analyser (SARA) from Swedish Institute of Space Physics developed in collaboration with ISRO's Vikram Sarabhai Space Centre — besides a RAdiation DOse Monitor (RADOM) from the Bulgarian Academy of Sciences.

The inclusion of US instruments on Chandrayan-1 would further strengthen the cooperation between India and USA in the field of space research which dates back to the very beginning of the Indian space programme

(*Source:* ISRO Press Release)

First custom-made bladders transplanted

According to a research report at least seven patients had received new bladders that have been engineered from a plug of tissue grown from their own, dysfunctional bladders. Researchers claimed that such custom-made bladders grown from patients' own cells have been successfully transplanted and work, in some cases for years. Dr. Anthony Atala, Wake Forest University in North Carolina, and the leader of the research team opined that their research has shown that regenerative medicine techniques can be used to generate functional bladders that are durable. Patients given transplants of bladders made from their own cells, unlike those who are given organs transplants from either living or dead donors, would not need to take drugs to prevent organ rejection.

The patients were children and teens aged 4 to 19 who had poor bladder function because of a congenital birth defect that causes incomplete closure of the spine. According to Atala, a urinary surgeon and an expert in regenerative and stem cell science, their research suggests that regenerative medicine may

one day be a solution to the shortage of donor organs for those needing transplants.

Vitamin D and calcium may lower diabetes risk

Women with high intakes of Vitamin D and calcium appear to have a lower risk of developing type 2 diabetes, according to a team of Boston-based researchers led by Dr. Anastassios G. Pittas, of Tufts-New England Medical Centre. Dr. Anastassios G. Pittas and his colleagues analysed the data collected on 83,779 women having no history of diabetes, cardiovascular disease or cancer when they enrolled in the study. Vitamin D and calcium intake from foods and from supplements were evaluated every 2 to 4 years. A total of 4843 new cases of diabetes were documented over 20 years of follow-up.

According to researchers the latest guidelines set by the Institute of Medicine envisage that only 3 per cent of women in our cohort had adequate Vitamin D intake, and only 24 per cent had adequate calcium intake. Total Vitamin D intake was not significantly associated with type 2 diabetes, but there was a difference when it came to Vitamin D supplements. The team saw a 13 per cent lower risk of diabetes among women in the highest versus the lowest category of Vitamin D intake from supplements.

Women with the highest total calcium intake had a 21 per cent lower risk of diabetes than those with the lowest intake. In this case, the source of calcium didn't make much difference: the risk was 18 per cent lower among women in the highest versus the lowest category of calcium intake from supplements. Overall, the lowest risk of diabetes was observed among women with the highest combined intakes of calcium and Vitamin D compared with those with the lowest.

(*Source:* Diabetes Care)

Viruses 'trained' to build tiny batteries

Researchers trying to make tiny machines have turned to the power of nature, engineering a virus to attract metals and then using it to build minute wires for microscopic batteries. The resulting nanowires can be used in minuscule lithium ion battery as electrodes, which in turn would be used to power very small machines.

An international team of researchers, led by a group at the Massachusetts Institute of Technology, used the M13 virus, a simple and easily manipulated virus. They modified the M13 virus' genes so that its outside layer, or coat, would bind with certain metal ions. They then incubated the virus in a cobalt chloride solution so that cobalt oxide crystals mineralised uniformly along its length.

Next a bit of gold was added to get the desired electrical effects. Viruses cannot reproduce on their own but must be grown in cells, in this case, bacteria. Virus inject their genetic material and then the cells pump out their copies. According to researchers, viruses ultimately form orderly layers.

The resulting nanowires worked as positive electrodes for battery electrodes. The researchers hope to build batteries

that range from the size of a grain of rice up to the size of existing hearing-aid batteries. Each virus, and thus each wire, is only six nanometres — six billionths of a metre — in diameter, and 880 nanometres long. Earlier researchers have previously used viruses to assemble semiconductor and magnetic nanowires.

Stem cells could boost stroke recovery

In rat studies, they also show promise against cerebral palsy.

Researchers have claimed that they have successfully reduced the effects of stroke in rats by transplanting stem cells into the rodents' brains. According to them the treatment also seemed to help rats fight a condition similar to human cerebral palsy. However, as of now it cannot be guaranteed that the treatment will work in humans. According to Cesario V. Borlongan, Associate Professor of Neurology at the Medical College of Georgia in Augusta, a member of the research team the tests in people could begin as early as next year. Even then the treatment is not expected to totally cure stroke or cerebral palsy, still, it could help.

According to Borlongan, despite decades of research, stroke remains extremely common and very difficult to treat. Thousands of people suffer strokes each day, but only few could access to newer remedies such as tPA, a powerful clot-busting drug. Cerebral palsy, a disabling neurological disorder of childhood, currently has no effective treatment.

However, because they have the ability to transform themselves into various types of body cells, stem cells have been thought to offer hope as a means of regenerating diseased or injured tissues. In fact, neuroscientists have been experimenting with stem cell transplants in animals for several years, but with mixed results.

In the new study, Borlongan and his colleagues transplanted human bone marrow cells into the brains of rats who had suffered strokes. In their study, the researchers avoided stem cells sourced from embryos or foetuses, which is still being debated on ethical and social grounds. Movement skills in the stroke-afflicted rats improved by 25 per cent after stem cell treatment, according to Borlongan. The improvement came even though the treatment was given seven days after a stroke. A 25 per cent improvement could translate into significant changes in how human patients get around. Bedridden patients may be able to use a wheelchair, and wheelchair-bound patients might move up to a walker, he said. Researchers also observed about a 25 per cent improvement in treated rats affected with a condition equivalent to human cerebral palsy. However, the researchers only watched them for 14 days. Unlike the rats in the stroke study, these rodents were injected with rat — not human — stem cells.

Beware of the telephone sets and computer keyboards!

Textbooks often teach us that most of the common infection — colds, flu,

diarrhoea — are transmitted environmentally either through the air, water or personal contact including the surfaces we touch. According to Charles Gerba, a microbiologist and clean water expert at the University of Arizona, people often under-rate surfaces they come in contact at their place of work, at home or other places they visit.

Experts believe that telephones, computer keyboards and sinks are more potential sources of infection than the doorknobs and elevator buttons. Based on dozens of surveys conducted on bacteria and viruses in workplaces and homes, Gerba asserts that people are usually cautious about the wrong things. According to him chances that doorknobs could be potential sources of infection are usually low as they are not moist. Therefore, one need not fear a doorknob too much.

Germs do not stick where people believe they will as has been revealed by a recent informal survey. An analysis of the survey data by Gerba illustrates how microbes take advantage of misconceptions to propagate themselves. Two computer keyboards, for example, were found to carry far more bacteria than an elevator button, the handles and button on the communal microwave oven or the office water fountain. Gerba warns that keyboards and telephones — especially when they are shared — are among the most germ-laden places in home or offices. Keyboards seem to be like a lunch table for germs as a lot of studies have revealed that on an average these harbour 400 times more bacteria than the average toilet seat. The main reason for such a dismal picture seems to arise due to the fact that usually nobody cleans the desktop. It is, therefore, perhaps not surprisingly, that teachers have the highest exposure to bacteria and viruses, as has been found by Gerba through his surveys. Accountants, bankers and doctors also tend to have microbe-laden offices, while lawyers came out surprisingly clean in the germ-count stakes.

A technique is followed to have an overall bacteria count for the general surveys. Swabs of each surface are sent to Gerba's lab, where these bacteria cultures are done in a lab dish. The growth of whatever bacteria are present can be used to estimate an overall load of germs, including harmless E. coli bacteria — which are found in the gut and are an indicator of what scientists delicately call "faecal contamination". Some other bacteria usually present are Klebsiella pneumonia, Streptococcus, Salmonella and Staphylococcus aurous, some of which cause disease and some of which do not. And where there are bacteria, there can be viruses, which can stick onto a clean and dry surface for days and to a wet surface for weeks.

According to experts such knowledge may be particularly useful as the pandemic of H5N1 avian influenza may be a real threat in future. While the virus currently infects birds almost exclusively, experts say it shows the greatest potential of any virus in decades to cause a human pandemic. If it begins to spread, basic hygiene would be essential to avoid infection.

Gerba notes that people tend not to know where the most infectious places are. For example, the bathrooms, toilet

taps and their doors. Bathroom sinks, however, are another source of infection as they are usually high in bacterial counts because they have everything bacteria like. It's wet, it's moist. In a home we usually find more E. coli in a sink than a toilet. Usually, public urinals are usually the dirtiest. All taps, door and flush handles and even walls' surfaces may be laden with bacteria.

German scientists synthesise a new compound

According to a research paper that appeared in the Journal of Biological Chemistry — an American Society for Biochemistry and Molecular Biology journal — Gunter Fischer and his colleagues at the Max-Planck Research Unit for Enzymology of Protein Folding in Germany have succeeded in synthesising a new compound that dramatically decreases the damage to neurons in rats demonstrating stroke symptoms**.**

Brain strokes area is the leading cause of death world over and also the most common cause of adult disability. An ischemic stroke occurs when a cerebral vessel occludes, obstructing blood flow to a portion of the brain. Currently, there is only one approved stroke therapy, tissue plasminogen activator, which targets the thrombus within the blood vessel. Because of the lack of available stroke treatments, neuroprotective agents have also generated as much interest as thrombolytic therapies.

The immuno suppressive drug FK506 (also known as Tacrolimus or Prograf.) is often administered to patients receiving transplants to prevent organ rejection. Derivatives of the drug are also commonly used in the treatment of auto immune diseases. FK506 inhibits T-cell activation by binding to members of the FK506-binding protein (FKBP) family. Interestingly, FK506, and several molecules with similar structures, also demonstrate neuroprotective and neuroregenerative effects in a wide range of animal models mimicking Parkinson's disease, dementia, stroke, and nerve damage.

Gunter Fischer and his colleagues have now determined that neuro protective FK506 derivatives specifically target a receptor called FKBP38. According to Fischer high FKBP38 activity in neuronal cells trigger mechanisms leading to programmed cell death. Inhibition of FKBP38 make cells more predisposed to survive. The scientists also synthesised a molecule that specifically inhibits FKBP38 and administered it to rats that were experiencing stroke symptoms. Fischer and his colleagues found that their compound protected the rats' neurons and also caused neural stem cell proliferation and neuronal differentiation. Animals with symptoms of disabilities, similar to those due to strokes, also showed improvement when they were given the synthetic drug. These results suggest potential therapeutic application specific FKBP38 inhibitors in the treatment of neuro degeneration following stroke and a number of other diseases.

(*Source:* http://www.asbmb.org)

Triple discovery hints at extra-solar planets

A team of astronomers had found three enticing Neptune-sized planets orbiting a distant star. The three planets were found after a two-year monitoring of the star using a 3.6m telescope at the European Southern Observatory (ESO) in La Silla, Chile. The discovery may prove to be a further step towards the goal of finding another Earth. More than 170 planets outside our own Solar system have been spotted in the past decade or so. But almost all of them have been gaseous Jupiter-sized giants that move around their star at a close range. Their atmosphere would be too hot and too dense to have liquid water, an essential ingredient for life as we know it.

A team led by Christophe Lovis from the Geneva Observatory in Switzerland located a smaller planetary system orbiting the star HD 69830. The star is 41 light years from Earth in the Puppis constellation and is about four-fifths the mass of our Sun. The three planets are quite large, being 10, 12 and 18 times larger in mass than the Earth. That makes them about the size of our Neptune, although a lot smaller than Jupiter, the biggest planet in our Solar System, and they appear to be solid planets too, made of rock, not gas.

The two innermost planets are probably so close to HD 69830 that they would be blisteringly hot, but the outermost one lies in what planet experts call the "Goldilocks zone" — a comfortable distance where water could exist as a liquid. Another discovery is that HD 69830 also hosts, like our Sun, an asteroid belt, the rubble left over from the building of planets from dust and gassy debris that clump together through gravitational attraction.

It may be too far fetched, according to researchers, to suggest that these planets contain life or the conditions for it, and it would be ludicrous anyway to think of them as a potential home away from home, given that our puny chemical rockets and their passengers could never reach there. But it shows that with patient searching and the right tools, astronomers can uncover ever-smaller exoplanets in ever-wider orbits from their star, which may one day lead to finding copies of Earth.

According to Michel Mayor, a member of the research team who is also from the Geneva Observatory, the planetary system around HD 69830 clearly represents a Rosetta stone in our understanding of how planets form. He was referring to the stone that opened the way to understanding the hieroglyphics of ancient Egypt. No doubt it will help us better understand the huge diversity we have observed since the first extrasolar planet was found 11 years ago, asserts Mayor.

(*Source:* NASA News)

A forward step in fusion research

A fusion reactor in which controlled fusion reaction could be made use to produce huge amount of energy has been a long cherished dream of physicists. In a fusion reactor, very high speed particles are made to collide together to form a charged gas called a plasma. This plasma is contained inside a doughnut-

shaped chamber called a tokamak by powerful magnetic coils. In the various designs of tokamaks developed so far in different parts of the world, none has achieved a self-sustaining fusion event for longer than about five seconds, and that too at a cost of using up far more energy than was yielded.

In 2005, a consortium of countries has signed a deal to build the International Thermonuclear Experimental Reactor (ITER) in southern France, which could serve as a test bed for an eventual commercial design. However, experts associated with designing ITER are faced with many challenges. One of them is a phenomenon called edge localised modes, or ELMs. These are sudden fluxes or eddy in the outer edge of the plasma that erode the tokamak's inner wall — a highly expensive metal skin that absorbs neutrons emitted from the plasma. Erosion means that the wall has to be replaced more often, which thus adds hugely to costs. Eroded particles also have a big impact on the plasma performance, diminishing the amount of energy it can deliver.

Physicists working in the United States believe they have cracked the problem facing man-made nuclear fusion, touted as the cheap, safe, clean and almost limitless energy source of the future. According to a team of researchers led by Todd Evans of General Atomics, California, the problematic ELMs can be controlled cleverly. They found that a small resonant magnetic field, derived from special coils located inside a reactor vessel, creates "chaotic" magnetic interference on the plasma edge, which stops the fluxes from forming. The experiments were conducted at the General Atomics' DIII-D National Fusion Facility, a tokamak in San Diego. Nuclear fusion is the process which enables the Sun to radiate energy. In the case of our star, hydrogen atoms are forced together to produce helium. On Earth, the fusion would take place in a reactor fuelled by two isotopes of hydrogen — deuterium and tritium — with helium the waste product. Deuterium is present in seawater, which makes it a virtually limitless resource. Tritium would be derived from irradiating the plentiful element lithium in the fusion vessel. Initially very high temperature, of the order of 10^8 ^oC, is needed to kickstart the fusion process, which then could be sustained by tiny amounts of fuel pellets.

ITER is designed to be a test bed of fusion technologies, with a construction period of about 10 years and an operational lifespan of 20 years. The partners of the project are the European Union (EU), the United States, Japan, Russia, China, India and South Korea. If ITER works, a prototype commercial reactor will be built, and if that works, fusion technology will be rolled out across the world. Other problems facing fusion technology include the challenge of creating self-sustaining plasma and efficiently containing the plasma so that charged particles do not leak out.

Cosmic telescopes!

Researchers have evolved yet another innovative technique to peep deeper into the mysteries of the universe. A research

team led by a Johns Hopkins University astronomer have used massive clusters of galaxies as "cosmic telescopes". What they have found may be infant galaxies born in the first billion years after the beginning of the universe. According to Holland Ford, a professor in the Henry A. Rowland Department of Physics and Astronomy at the university's Krieger School of Arts and Sciences, if these findings are confirmed, the extra magnification provided by these gargantuan natural telescopes would give astronomers their best-ever view of galaxies as they formed in the early universe, more than 12 billion years ago. Holland Ford is the head of the Hubble Space Telescope's Advanced Camera for Surveys Science Team, which also includes researchers from the Space Telescope Science Institute, PUC in Chile, and other universities around the world.

Announcing the team's results Ford said that their team's spectroscopic observations were made possible by gravitational lenses, the bending of light caused by gravity's warping of space in the presence of such massive objects as clusters of galaxies. Explaining the basic idea of gravitational lenses Ford recalled that one of Einstein's most startling predictions was that a gravitation field can be thought of as a distortion of space and time. Gavitational lensing by massive clusters of galaxies that have about 1 million billion times more mass than the sun provide one of the most striking confirmations of Einstein's prediction.

Ford asserts that our view of distant galaxies behind a cluster can be magnified by amounts that could vary from barely detectable to as many as 50 or 100 times normal size, depending on the location of the galaxy and the distribution of mass within the cluster. The clusters are, in effect, giant cosmic telescopes that allow astronomers to find and study distant galaxies that otherwise would be too faint to study.

Astronomers want to know when the first galaxies formed, how large and how bright galaxies are at birth, and how galaxies grow into large mature galaxies like our home Milky Way galaxy. The research team is searching for infant galaxies that are less than a billion years old by comparing images of strongly lensing clusters taken by the Hubble Space Telescope with images of the same clusters taken by the Magellan, the Very Large Telescopes (VLT) and Gemini telescopes. The infant galaxies are so far away their light is almost or entirely redshifted to wavelengths that cannot be detected with Hubble's Advanced Camera for Surveys, but can be detected with infrared detectors on the world's largest telescopes.

Using this technique, the research team has searched for infant galaxies behind 14 lensing clusters. If longer spectroscopic observations of the three brightest candidate galaxies confirm that they are indeed in the early universe, these galaxies will provide astronomers their clearest view yet of the youngest galaxies ever seen.

(*Source:* Science Daily online)

60-year-old Plutonium questions resolved

Scientists have claimed to solve a

question about the nature of plutonium that has remained a mystery ever since the first nuclear device was detonated. It is known that plutonium behaves like no other element in nature. The bonding of its electrons causes its crystal structure to be uneven, similar to a mineral, and the nucleus is unstable, causing the metal to spontaneously decay over time and damage the surrounding metal lattice. First batches of the plutonium metal used in that device were too brittle due to the mineral-like structure of its crystal. In order to make the metal machinable, the high-temperature, high-symmetry cubic structure of plutonium needed to be retained at room temperature. In the first nuclear device scientists achieved this by adding a small amount of gallium.

According to Kevin Moore, a staff scientist in the Materials Science and Technology Division at Lawrence Livermore National Laboratory, U.S.A. there was never a clear explanation as to why gallium stabilised the ductile cubic structure over the low-symmetry mineral-like structure; they just did it and it worked. For the first time, researchers have determined why gallium works. In pure plutonium, the bonds between Pu atoms are very uneven, causing the metals high propensity to adopt a low-symmetry structure. However, when a gallium atom is put in the plutonium lattice, it causes the bonds to become more uniform and thus leads to the high-symmetry cubic structure. Gallium evens out the plutonium bonds, asserts Moore. The calculations strongly illuminate why gallium stabilises the machinable cubic structure to room temperature. Through a series of calculations, Moore and his Livermore colleagues, Per Söderlind and Adam Schwartz, and David Laughlin of Carnegie Mellon University have produced these results. The team next proposes to test their calculations in the laboratory.

New heart tissue grown in rats

Australian doctors have successfully grown new beating heart tissue in rats in a process that they claim could be used for people someday. The researchers say the heart tissue developed by them beats spontaneously with its own rhythm and could be used to repair heart attack damage and other life-threatening ailments. They say it is the first step to creating organs to replace diseased and injured body parts.

According to Dr. Wayne Morrison, who led a team of scientists from the Bernard O'Brien Institute of Microsurgery this is a major breakthrough for Australian medical science. Though it may still be too early to put it in practice, but nevertheless it opens up the possibilities of growing living tissue: taking the patient's cells and growing inside their own body living tissue that can be used to repair their own organs. The ground-breaking tissue-engineering technique uses a subject's own heart cells to grow new tissue in a special chamber implanted in the subject's own body, which eliminates the risk of tissue rejection.

(*Source:* Science Daily)

Magnetic thrust: fields force matter into black holes

New observations confirm that magnetic fields provide a final galactic push needed to plunge cosmic matter into a black hole. The observations come from a system in the Milky Way called GRO J1655-40, which consists of a black hole and a normal star. Gas from the star is pulled toward the black hole, where it forms what's called an accretion disk. Angular momentum keeps the disc revolving around the black hole instead of falling into it. Until now, scientists weren't sure whether magnetic fields, radiation pressure, or heat alter the orbit and trigger that fall.

Unless something knocked them off course, the gases in the disk would continue to circle the black hole forever. "To get matter in toward the black hole, we have to change the orbits in the disk," says study leader Jon Miller

Using NASA's Chandra satellite observatory, Miller of the University of Michigan in Ann Arbor, U.S.A. and his team collected data on X- rays emitted from the J1655 system. They found that the X- rays came from a wind blowing from the disk, so some force must propel the wind past the black hole's gravitational pull. After simulating the wind on a computer, the researchers conclude that only magnetic fields could create such a force. The team had ruled out a wind fuelled by heat from the core of the disc or by pressure from radiation blasting out of the disk. A heat-driven wind would have been hotter than the one that the researchers observed, and radiation pressure is too weak to drive that wind. Therefore, magnetic pressure really was the only viable means remaining, according to Miller.

Such pressure could upset the gas disc's orbit in two ways. The magnetic fields could push the wind outward like a spring, or the force of the spinning disk could fling the wind away from the disk's centre. Either disruption of the disc's orbit would cause some matter to spiral downward. Though most astrophysicists expected magnetic fields to play a role in black holes, the finding of the researchers is an important evidence to support that view because it is for the first time there is a clear evidence for wind coming off an accretion disc. According to Miller their finding could help astrophysicists understand the "complex give-and-take between galaxies and black holes.

(*Source:* Science News Online)

New finding about E Coli could help contain infections

Researchers at UT Southwestern Medical Center, USA have discovered a new receptor in a strain of Escherichia coli (E coli) that can be blocked to avert infection. The finding might help in developing better therapies to treat bacterial infections resulting from food poisoning, diarrhea or plague. The receptor, known as QseC, is used by a diarrhea-causing strain of E coli to receive signals from human flora and hormones in the intestine and express virulence genes to initiate infection.

In a study researchers have described how they used phentolamine, an alpha blocker drug used to treat

hypertension, to successfully impede signalling to the receptor. Without such signals, bacteria then pass blindly through the digestive tract without infecting cells. According to Dr. Vanessa Sperandio, Assistant Professor of Microbiology at UT Southwestern, U.S.A. and a member of the research team this receptor is found in many pathogens, so they could use this knowledge to design specific antagonists to block bacterial infections.

Prior research by Dr. Sperandio found that when a person ingests the more virulent enterohemorrhagic E coli, or EHEC — which is usually transmitted through contaminated food such as raw meat — it travels peacefully through the digestive tract until reaching the intestine. There, however, chemicals produced by the friendly gastrointestinal microbial flora and the human hormones epinephrine and nor-epinephrine alert the bacteria to its location. This cellular cross talk triggers a cascade of genetic activations prompting EHEC to colonize and translocate toxins into cells, altering the makeup of the cells and robbing the body of nutrients. An infected person may develop bloody diarrhoea or even haemolytic uremic syndrome, which can cause death in immune-weakened people, the elderly and young children.

The new study identifies QseC as the specific receptor by which EHEC senses the signals. When the receptor binds to signalling molecules, the bacterium can infect cells. Researchers tested the capacity of adrenergic antagonists, drugs such as alpha and beta blockers, to disrupt the receptor's sensing ability. They found that phentolamine binds to the QseC receptor and occupies the pocket that the receptor would use to recognise the host epinephrine and nor-epinephrine signals — thus blocking the QseC receptor from sensing the signals and preventing it from being able to express its virulence genes in cells. Dr. Sperandio opined that this knowledge could lead to further understanding of the signalling processes between microbes and humans and to the development of novel treatments of bacterial infections with antagonists to these signals.

New therapies are important because treating some bacterial infections with conventional antibiotics can cause the release of more toxins and may worsen disease outcome. The importance of the research findings can be magnified manifold because of the QseC receptor's existence in other types of bacteria. These include Shigella, which causes dysentery; Salmonella, which causes food poisoning and gastroenteritis; and Yersinia, which causes bubonic plague. All of them are infectious diseases that afflict thousands of people each year worldwide. Researchers are of the opinion that overuse of antibiotics has led bacteria to develop resistance to antibiotics, so a novel type of therapy is needed.

(*Source:* Sciencedaily)

NASA Satellite positioning software may aid in Tsunami warnings

University scientists using Global Positioning System (GPS) software developed by NASA's Jet Propulsion Laboratory, Pasadena, Calif., have

shown that GPS can determine, within minutes, whether an earthquake is big enough to generate an ocean-wide tsunami. This NASA-funded technology can be used to provide faster tsunami warnings.

A team led by Dr. Geoffrey Blewitt of the Nevada Bureau of Mines and Geology and Seismological Laboratory, University of Nevada, Reno, demonstrated that a large quake's true size can be determined within 15 minutes using GPS data. This is much faster than is possible with methods employed at present. Tsunami warning is a race against time asserts Dr. Seth Stein, Department of Geological Sciences, Northwestern University, and a member of the researcher team. Tsunamis travel at jet speed, so warning centres must accurately decide, within minutes, whether to issue alerts. This has to be done fast enough for the warning to be distributed to authorities in impacted areas so they can implement response plans. Together with seismometer and ocean buoy data, GPS adds another tool that can improve future tsunami danger assessments. However, the first level of alert for large earthquakes would always need seismology and ocean buoys to actually sense the tsunami waves. The advantage of including GPS in warning systems is that it would facilitate to quickly assess how much the ocean floor has moved, so that this information can directly set tsunami models into motion.

The new method, called GPS displacement, works by measuring the time radio signals from GPS satellites arrive at ground stations located within a few thousand kilometres of a quake. From these data, scientists can calculate how far the stations moved because of the quake. They can then derive an earthquake model and the quake's true size, called its 'moment magnitude.' This magnitude is directly related to a quake's potential for generating tsunamis.

As illustrated by the magnitude 9.2-9.3 Sumatra quake of December 2004, current scientific methods have difficulty in quickly determining moment magnitude for very large quakes. That quake was first estimated at 8.0 using seismological techniques designed for rapid analysis. Because these techniques derive estimates from the first seismic waves they record, they tend to underestimate quakes larger than about 8.5. That is the approximate size needed to generate major ocean-wide tsunamis. The initial estimate was the primary reason warning centres in the Pacific significantly underestimated the earthquake's tsunami potential.

The potential of GPS to contribute to tsunami warning became apparent after the Sumatra earthquake. GPS measurements showed that quake moved the ground permanently more than 1 centimetre as far away as India, about 2,000 kilometres away from the epicentre. The researchers hypothesised that if GPS data could be analysed rapidly and accurately, it could be possible to quickly indicate the earthquake's true size and tsunami potential.

To test the feasibility of their approach, the scientists used NASA's satellite positioning data processing

software to analyse data from 38 GPS stations located at varying distances from the Sumatra quake's epicentre. The software pinpoints a station's precise location to within 7 millimetres. Only data that were available within 15 minutes of the earthquake were used. Results indicated most of the permanent ground displacements occurred within a few minutes of the arrival of the first seismic waves. The analysis done by researchers inferred an earthquake model and a moment magnitude of 9.0, very near the earthquake's final calculated size.

(*Source:* NASA News)

Good news and a puzzle

Ozone layer on the upper strata of the Earth's atmosphere plays a vital role in protecting life on the surface from the harmful glare of the sun's strongest ultraviolet rays, which can cause skin cancer and other maladies. In the 1980s, when scientists noticed that manmade chemicals in the atmosphere were destroying this layer, it is not surprising that people all over the world were alarmed. Governments quickly enacted an international treaty, called the Montreal Protocol, to ban ozone-destroying gases such as CFCs then found in aerosol cans and air conditioners.

Today, almost 20 years later, reports continue of large ozone holes opening over Antarctica, allowing dangerous UV rays through to Earth's surface. Indeed, the 2005 ozone hole was one of the biggest ever, spanning 24 million sq km in area, nearly the size of North America. Listening to this news, one might be tempted to think that little progress has been made. However, this assertion may not be correct. While the ozone hole over Antarctica continues to open wide, the ozone layer around the rest of the planet seems to be shrinking. For the last 9 years, worldwide ozone has remained roughly constant, halting the decline first noticed in the 1980s.

The question is *why?* Is the Montreal Protocol responsible? Or is some other process at work? It's a complicated question. CFCs are not the only things that can influence the ozone layer; sunspots, volcanoes and weather also play a role. Ultraviolet rays from sunspots boost the ozone layer, while sulphurous gases emitted by some volcanoes can weaken it. Cold air in the stratosphere can either weaken or boost the ozone layer, depending on altitude and latitude. These processes and others have been presented in a review by a group of researchers from NASA and some universities in U.S.A. According to researchers, they measured ozone concentrations at different altitudes using satellites, balloons and instruments on the ground. Then they compared their measurements with computer predictions of ozone recovery. The calculations also took into account the known behaviour of the sunspot cycle, seasonal changes in the ozone layer, and Quasi-Biennial Oscillations, a type of stratospheric wind pattern known to affect ozone.

What researchers have found is both good news and also a puzzle. The good news: In the upper stratosphere (above roughly 18 km), ozone recovery can be explained almost entirely by CFC

reductions. The Montreal Protocol seems to be working at such heights, according to researchers. The puzzle: In the lower stratosphere (between 10 and 18 km) ozone has recovered *even better* than changes in CFCs alone would predict. Something else must be affecting the trend at these lower altitudes. The "something else" could be atmospheric wind patterns. This is because the winds are known to carry ozone from the equator to higher latitudes where it is destroyed. Changing wind patterns affect the balance of ozone and could be boosting the recovery below 18 km. This explanation seems to offer the best fit to the computer model of the researchers. However, other sources of natural or manmade variability may yet prove to be the cause of the lower-stratosphere's bonus ozone. Whatever be the real cause, if the trend continues, the global ozone layer should be restored to 1980 levels sometimes between 2030 and 2070. By then even the Antarctic ozone hole might close — for good.

(*Source:* NASA News)

Corkscrew Asteroid

Believe it or not the Earth has a "second moon" for early seven years. It is actually an Asteroid, only 20 metre in size, which has been going around our planet once a year. The asteroid is too small to see with the unaided eye — but it is there.

According to Paul Chodas of NASA's Near Earth Object Program at JPL, the Asteroid arrived in 1999 and it's been corkscrewing around Earth ever since. Because the asteroid is so small and poses no threat, it has attracted little public attention. But Chodas and other experts have been monitoring it, which according to him is a very curious object.

Most near-Earth asteroids, when they approach Earth, simply fly by. They come and they go, occasionally making news around the date of closest approach. This Asteroid since named 2003 YN107 is different: It came and it stayed. Astronomers believe that 2003 YN107 is one of a whole population of near-Earth asteroids that don't just fly by Earth. They pause and corkscrew in our vicinity for years before moving along. These asteroids are called Earth Co-orbital Asteroids or "co-orbitals" for short. Essentially, they share Earth's orbit, going around the Sun in almost exactly one year. Occasionally a co-orbital catches up to Earth from behind, or vice versa, and the dance begins: The asteroid, while still orbiting the sun, slowly corkscrews around our planet, which in other words means that their orbit as seen from the earth appears like a corkscrew.

These asteroids, however, are not truly captured by Earth's gravity, notes Chodas. But from our point of view, it looks like we have a new moon. Astronomers know of at least four small asteroids that can do this trick: 2003 YN107, 2002 AA29, 2004 GU9 and 2001 GO2. There may be more as Chodas believes the list will grow as asteroid surveys improve in sky coverage and sensitivity. At the moment, only two co-orbitals are actually nearby: 2003 YN107 and 2004 GU9. The others are scattered around Earth's orbit.

2004 GU9 is perhaps the most interesting. It is about 200 metre in size,

which is relatively large compared to other such asteroids. And according to latest calculations it has been looping around Earth for 500 years—and may continue looping for another 500. It's in a remarkably stable "orbit."

Right now, however, researchers are paying more attention to 2003 YN107 for one simple reason: it's about to leave the earth's orbit. The asteroid's corkscrew path is likely to come within 3.4 million km of Earth sometime in June 2006, when it will be slightly closer than usual. Earth's gravity will then give the asteroid the push it needs to leave. This would give astronomers a rare chance to observe the asteroids moving out of the earth's orbit. However, it won't be gone forever. In about 60 years 2003 YN107 will lap Earth again, resuming its role as a temporary, corkscrewing moonlet. In due course, other coorbitals will do the same.

Each encounter is an opportunity for study—and possibly profit. Even the most powerful telescopes cannot see much of these tiny asteroids; they're just specks in the eyepiece. However, Chodas is optimistic that one day, when the space program is more advanced it might be possible to visit, explore the moonlets and tap their resources and then they would not be just an object of curiosity as they are today.

(*Source:* NASA NEWS on line)
(Compiled and edited by: R. Joshi)

Book Review

Wings of Fire

A.P.J. Abdul Kalam with Arun Tiwari
Publisher: Universities Press (India) Ltd
3-5-819, Hyderguda,
Hyderabad - 500 029, pp. 179, Rs. 200.

India has made great strides in space, nuclear power and, above all, missile technology. Indeed *Agni, Prithvi, Akash, Trishul* and *Nag* have become household names in India and at the same time have contributed to raising the nation to the level of a missile power of international reckoning. The man behind missile technology, aptly called the 'missile man', is none other than our honourable President, Dr. A.P.J. Abdul Kalam. Born in 1931, the son of a little educated boat-owner in Rameswaram, Tamil Nadu, Dr. Kalam had an unparalleled career as a defence scientist, culminating in the highest civilian award of India – the Bharat Ratna. However, Dr. Kalam rose to the position he is enjoying today by dint of his personal and professional struggles. An account of Dr. Kalam's life can, therefore, be inspiring and motivating to youth, particularly those belonging to the unprivileged section of the society.

The book under review is an autobiography of Dr. Kalam written by Arun Tiwari through a long series of sittings with the former. It is divided into four major chapters titled Orientation, Creation, Propitiation and Contemplation.

The first Chapter 'Orientation' described the struggles of Dr. Kalam's boyhood and youth, bringing alive everyday life in a small town in South India named Rameswaram, and the inspirational roles of educators. Dr. Kalam's dream to become an Air Force pilot, got frustrated and he had to contend with the job of Senior Scientific Assistant at the Directorate of Technical Development & Production [DTD&P (Air)] of the Ministry of Defence. Later, he was selected as a rocket engineer by the Indian Committee of Space Research (INCOSPAR). This chapter also narrates Dr. Kalam's efforts to design and develop a hovercraft christened *Nandi* which, however, did not finally materialise.

The Chapter 'Creation' is mainly about the contribution of Dr. Kalam at Indian Space Research Organisation (ISRO). He was made the Project Manager of the Satellite Launch Vehicle (SLV) Programme. However, the first experimental flight trial of SLV-3 on 10 August 1979 met with failure. This greatly disappointed Dr. Kalam. But, he was not to be cowed down and, on 18 July 1980, SLV-3 was successfully launched.

The third Chapter 'Propitiation' highlights Dr. Kalam's role at Defence Research and Development Laboratory (DRDL) in the development of missiles under India's prestigious Integrated Guided Missile Development Programme (IGMDP). The last Chapter 'Contemplation' summarises some ideas of Dr. Kalam concerning technology, its management and the philosophy behind Technology Management.

The book under review is in essence a story of a scientist who, time and again, was tested by failures and setbacks but was finally crowned with success and fame. As has been rightly remarked in the book, one 'need not be disheartened about life. Problems are a part of life. Suffering is the essence of success.' In this context it is worth quoting the following lines appearing in the book:

God has not promised
Skies always blue,
Flower-strewn pathways
All our life through;
God has not promised
Sun without rain,
Joy without sorrow
Peace without pain.

However, solace is also assured in terms of the following lines:

But God has promised
Strength for the day,
Rest for the labour
Light for the day.

There are words of wisdom scattered here and there in the book. It will be worthwhile quoting the following lines:

Happiness, satisfaction, and success in life depend on making the right choices, the winning choices. There are forces in life working for you and against you. One must distinguish the beneficial forces from the malevolent ones and choose correctly between them.

The following lines may also prove to be rewarding reading indeed:

Total commitment is the common denominator among all successful men and women. Are you able to manage the stresses you encounter in your life? The difference between an energetic and a confused person is the difference in the way their minds handle their experiences. Man needs his difficulties because thay are necessary to enjoy success.

Then, how are the following words from a struggling Dr. Kalam of yesteryears:

So far, I had believed that the sky was the limit, but now it appeared that the limits were much closer. There are boundaries that dictate life: you can only lift so much weight; you can only learn so fast; you can only work so hard; you can only go so far.!

Also, reflecting on the title are the following lines in the book:

Let the latent fire in the heart of every Indian acquire Wings, and the glory of this great country light up the sky.

The book ends with the following hope and prayer:

I earnestly hope and pray that the development ... will eventually make our country strong and prosperous, a "developed" nation.

There are many inspiring anecdotes in the book, too. Certainly, a must-read not only for youth but for readers of all age and also those belonging to various cross-sections of the society.

P.K. MUKHERJEE
43, Deshbandhu Society
15, Patparganj
Delhi 110 092.