Our Spaceship Earth

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... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...
Polio: The Elusive Frontier

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

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

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

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

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

But, then why did our polio eradication strategy fail in Uttar Pradesh and Bihar? There are three types (strains) of polioviruses – Type 1, Type 2 and Type 3. Though all the three types can produce the disease, Type 1 is the most prevalent and Type 3 much rarer. The last case of Type 2 polio anywhere in the world was in 1999. The trivalent oral polio vaccine (TOPV) contains all the three strains of live weakened virus seeking to create immunity against all the three known polio types. The administration of this vaccine triggers a local infection and prompts immune response in the intestines. Diarrhoea and other competing viruses in the intestine, which are particularly common in Uttar Pradesh and Bihar, prevent this. It is also possible that that the three strains of polio vaccine compete with each other further reducing its efficacy.

Since Type1 poliovirus is widespread in Uttar Pradesh and Bihar, the India Expert Advisory Group for Polio Eradication has recommended increased use of the

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One of the greatest scientific achievements in the year 2006 was the proof of the Henri Poincaré’s conjecture. It was a problem of topology, the mathematical study of abstract shape. The significance of this achievement can be guessed from the following statement made by the science magazine, *Discover*: “If, in the year 2100, *Discover* runs a feature on the top advances in science in the 21st century, the proof of the Poincaré conjecture is still likely to be the number-one story in mathematics.”

The conjecture was proposed by Poincaré in 1904. This was described as a way to determine the structure of space. It was stated as: “Consider a compact 3-dimensional manifold V without boundary. Is it possible that the fundamental group V could be trivial, even though V is not homeomorphic to the 3-dimensional sphere?” This became one of the greatest unsolved problems of mathematics. It also became one “Millennium Prize Problems.”

The statement of the Poincaré conjecture cannot be understood by laypersons without a strong mathematical background. But we can understand the significance of Poincaré conjecture about the structure of space in a general way. We live in a three-dimensional universe and we have every freedom to move in all possible directions – forward and backward, up and down, and left and right. Now, though we have freedom to move in every direction, still we are not in a position to find the shape of the universe. This is because we cannot go out of the universe and look down on it to find its shape. Poincaré made strides in understanding three-dimensional spaces – the kind, for instance, that an airplane flies through, made up of north-south, east-west and up-down measurements. His question, or conjecture, was whether two-dimensional calculations could be easily modified to answer similar questions about 3-D spaces. He was pretty sure the answer was yes but could not prove it mathematically and it remained unsolved for more than a hundred years. An answer to the question would help scientists better understand the shape of the universe.

Many important mathematicians made serious attempts to solve the problem, but no headway could be made till the 1950’s when some progress was made. In 1950’s and 60’s it was found that it was easier to solve the problem for higher-dimension manifolds. Theorems for higher-dimension manifolds were proposed by many mathematicians including Stephe Smale, John Stallings, and Andrew Wallace. However, the Poincaré conjecture remained unsolved until 2002-03 when Grigori Perelman, a Russian mathematician, posted three papers on the Internet. These three papers together constituted a 58-page document. Perelman did not say that he has solved the Poincaré conjecture. In his three papers he outlined the key steps required to solve the Geometrization conjecture proposed by William Thurston, an American mathematician.
mathematician in the 1970s. The Poincaré conjecture is the direct consequence of Geometrization conjecture or the general conjecture. This means once the Geometrization conjecture is solved the Poincaré conjecture stands automatically solved. As with many great discoveries, Perelman’s work was not immediately understood. It almost took four years for the mathematicians from all over the world to understand that Perelman had actually solved the Geometrization conjecture. In the process they produced a 500-page version of Perelman’s original document and finally they were convinced that Perelman had actually solved the Poincaré conjecture.

Poincaré was regarded as “the living brain of rational sciences” of his time. He was one of France’s greatest mathematicians. His contributions to theoretical physics were equally significant. He also excelled as a philosopher of science. He is referred to as the last universalist in mathematics. This means he had command over the entire field of mathematics. Thus The Oxford Dictionary of Scientists wrote: “As Poincaré is commonly referred to as the great universalist – the last mathematician to command the whole subject – on account of his work would have to cover the whole mathematics. In pure mathematics he worked on probability theory, differential equations, the theory of numbers, and in Analysis situs (1895; Site analysis) virtually created the subject of topology.”

Poincaré is the founder of the field called topology, or more precisely algebraic topology. He not only created the field but also organised the scattered results known previously and set agenda for future mathematicians to work in the field. He developed a number of techniques, which became indispensable tools for the development of topology. He made important contributions to almost all branches of applied mathematics – celestial mechanics, fluid mechanics, optics, electricity, telegraphy, capillarity, elasticity, thermodynamics, potential theory, quantum theory, relativity theory, and cosmology. His work on qualitative theory of differential equations had far reaching implications in celestial mechanics. He utilised his theory of differential equations to deal with such questions as long-term stability of a dynamical system. He published his results concerning this theory in his paper Les méthodes nouvelles de la mécanique céleste (‘New Methods in Celestial Mechanics’). This paper is regarded as the greatest advance in celestial mechanics since Newton’s Principia.

Poincaré worked on relativity. His paper on relativity was published in 1905, the same year Albert Einstein published his paper on special theory of relativity. In fact, Einstein published his paper after one month of Poincaré’s publication. Poincaré’s paper was titled ‘Partly kinematic, partly dynamic’. Poincaré in his first paper on relativity included his correction of Lorentz’s proof related to Lorentz transformation. It should be noted that the term “Lorentz transformation” was coined by Poincaré. It appears that Poincaré and Einstein never interacted with each other. Even Einstein claimed that he never read Poincaré’s papers on relativity. However, later in his life, Einstein regarded Poincaré as one of the pioneers of relativity. Einstein once said: “Lorentz had already recognised that the transformation named after him is essential for the analysis of Maxwell’s equations, and Poincaré deepened this insight still further...”

Poincaré had an unusual memory power. Commenting on this quality of Poincaré, E. T. Bell wrote: “His principal diversion was reading, where his unusual talents first showed up. A book once read – at incredible speed – became a permanent possession, and he could always state the page and line where a particular thing occurred. He retained this powerful memory all his life. This rare faculty, which Poincaré shared with Euler, who had it in lesser degree, might be called visual or spatial memory. In temporal memory – the ability to recall with uncanny precision a sequence of events long passed – he was also unusually strong.”

It is interesting to note that when he had established himself as the greatest mathematician of his time, Poincaré submitted himself to the Binet-Simon test (or the Binet test, as it is often referred to) and the results of the test were so hopeless that he could at best rated as an imbecile. The Binet-Simon test, developed by two French psychologists Alfred Binet (1857-1911) and T. Simon (1873-1961), is an intelligence test that consists of questions, problems, and things to do, graded in terms of mental age.

Henri Poincaré was born in Nancy, France on 29 April 1854. His full name was Jules Henri Poincaré. His
father Leon Poincaré (1828-1892) was a physician of repute and Professor of Medicine at the University of Nancy. One of his cousins, Raymond Poincaré became the President of the French Republic (1913-1920). Poincaré’s sister married to the spiritualist philosopher Emile Boutroux (1845-1921). In his childhood, Poincaré fell seriously ill with diphtheria. Because of this illness he could not speak for a year.

Poincaré was first taught by his gifted mother, Eugenie Launois (1830-1897) In 1862, at the age of eight he entered Lyceé in Nancy for his formal education. This institution was later renamed as Lyceé Henri Poincaré. The University of Nancy was also named after Poincaré. After spending 11 years at the Lyceé, his schooling was interrupted by the Franco-Prussian war. His home province of Alsace-Lorraine was much affected by the German invasion. During the war Poincaré learned German language mostly because of reading the news bulletins in German, as there was no way of getting news in French during the occupation. Later his knowledge of German helped him to maintain contacts with German mathematicians. He graduated from the Lyceé in 1871 with a Bachelor's degree in letters and science.

Poincaré did exceedingly well in the Lyceé. He stood first in all subjects except music and physical activities. In 1873, he took entrance examination for both the École Polytechnique and École Normale Superieure. He stood first in the examination for the École Polytechnique and fifth for École Normale Superieure. At that stage of his life, Poincaré was planning to become an engineer and so he opted for the polytechnique. Like in school, he performed brilliantly in all subjects at the Polytechnique except drawing and experimental work. Because of his poor performances in drawing and experimental work, Poincaré came second in the final examination of the Polytechnique.

After coming out of the Polytechnique in 1875 Poincaré joined the École des Mines (School of Mines), where he studied for four years for qualifying as a mining engineer. He not only qualified the examination for the mining engineering in 1879 but also wrote a doctoral thesis on the properties of function defined by differential equations. He briefly worked as a mining engineer before he finally decided to pursue a career in mathematics. He worked as an ordinary engineer in charge of the mining services in Vesoul. His doctoral supervisor was Charles Hermite (1822-1901). It may be noted that Hermite’s most famous contributions to mathematics are: Hermite’s polynomials, Hermite’s differential equation, Hermite’s formula of interpolation and Hermite’s matrices. Hermite was the first to solve a fifth-degree equation. Poincaré’s thesis was on differential equations. The examiners of Poincaré’s thesis were satisfied with the first part of it but they were critical about the rest. They recommended the award of the degree but at the same time they commented: “..remainder of the thesis is a little confused and shows that the author was still unable to express his ideas in a clear and simple manner. Nevertheless, considering the great difficulty of the subject and the talent demonstrated, the faculty recommends that M Poincaré be granted the degree of Doctor with all privileges.”

Poincaré joined the University of Caen in Normandy as a Professor of Mathematical Analysis. His first major discovery in mathematics – the occurrence of non-Euclidean geometry in the theory of Fuchsian functions (today Fuchsian functions are called automorphic functions) – was made at Caen. The description of automorphic functions is beyond the scope of this article. However, we quote below Poincaré describing how he discovered automorphic functions: “For fifteen days I strove to prove that there could not be any functions called Fuchsian functions. I was then very ignorant; every day I seated myself at my worktable, stayed an hour or two, tried a great number of combinations and reached no results. One evening, contrary to my custom, I drank black coffee and could not sleep. Ideas rose in crowds; I felt them collide until pairs interlocked so to speak, making a stable combination. By the next morning I had established the existence of a class of Fuchsian functions, those which come from the hypergeometric series; I had only to write out the results, which took but a few hours.”

Poincaré remained at Caen till 1881. From Caen he moved to the Paris University. His first appointment was as Professor-In-Charge of Analysis Conferences. In 1886, he was nominated for the Chair of mathematical physics and probability at the Sorbonne. He got the appointment mostly because of intervention and support of his mentor Hermite.

In 1887, Oscar II, King of Sweden and Norway, announced a mathematical competition as part of celebration of his sixtieth birthday. Poincaré won the competition for his Memoir on the three-body problem in celestial mechanics. In this memoir he included the following important results; i) first description of homoclinic points; ii) the first mathematical description of chaotic motion; and iii) the first major use of the idea of invariant integrals.

In his last years Poincaré published several articles...
on general and philosophical aspects of science, which were later published as books. When Poincaré wrote on the philosophy of science and scientific method, science was not a popular topic in France. He was a leading populariser of science of his time. Whitrow wrote: “After Poincaré achieved prominence as a mathematician, he turned his superb literary gifts to the challenge of describing for the general public the meaning and importance of science and mathematics.” Among his most popular and philosophical writings included Science and Hypothesis (1905, the original French version in 1901), Science and Method (1914, the original French version in 1908), and the Value of Science (1907, the original French version in 1904).

Poincaré opposed the philosophical views of Bertrand Russell and Gottlob Fregde who held the view that mathematics was a branch of logic. Contrary to their views Poincaré believed that intuition was the driving force of mathematics.

Poincaré won numerous prizes, medals and honours. In 1887, he was elected to the Paris Academy and in 1906 he became its President. He was the only member of the Academy to be elected to every one of the five sections of the Academy - geometry, mechanics, physics, geography, and navigation. In 1893, he was elected to the Bureau des Longitudes. In 1894 he was made a Fellow of the Royal Society of London. He was the first recipient of Sylvester Medal of the Royal Society. In 1908 he was elected to the Academie Francaise and he was elected its Director in 1912, the year in which he died.

Poincaré died on 17 July 1912. One year before his death he published an unfinished paper on periodic solutions of the three-body problem. He had taken this rather unusual step because he thought that he might not live to complete the paper. This became known as Last Geometrical Theorem of Poincaré. A young American mathematician George Birkhoff published the complete proof of the theorem in 1912. The first biography of Poincaré was written by one of the greatest geometers of France, Gaston Darboux (1842-1917) in 1913; that is, the year following Poincaré’s death.

It is worthwhile to remember what Poincaré had said on mathematical discoveries; “Mathematical discoveries, small or great are never born of spontaneous generation. They always presuppose a soil seeded with preliminary knowledge and well prepared by labour, both conscious and subconscious”. Poincaré believed that scientists and artists enjoy the same sense pleasure in their work. He wrote: “A scientists worthy of his name, above all a mathematician, experiences in his work the same impression as an artist; his pleasure is as great and of the same nature.”

We would like to end this write-up by quoting Poincaré: “One would have to have completely forgotten the history of science so as to not remember that the desire to know nature has had the most constant and the happiest influence on the development of mathematics.” This is perhaps true for all branches of science.

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(This article is a popular compilation of the important points on the life and work of Henri Poincaré available in the existing literature. The idea is to inspire the younger generation to know more about Poincaré. The author has given sources consulted for writing the article. However, the sources on the internet are numerous and so they have not been individually listed. The author is grateful to all those authors whose works have contributed to writing this article.)

Editor
Introduction

The present age is called the space age. It commenced a little more than five decades ago, with the launching of the Sputnik by the erstwhile Soviet Union in October 1957. Since then, we have been hearing about increasingly more daring adventures such as: Gagarin’s circling the Earth in 80 minutes; Armstrong’s setting foot on the Moon; Mariner and Venera missions to Mercury and Venus; landing of Vikings on Mars in search of life on that planet; distant space flights of the Voyagers to Jupiter, Saturn, Uranus and Neptune; the long-duration manned flights of the Salyut space stations; manoeuvres of space shuttles; rendezvous with Halley’s comet; and launching of the Hubble Space Telescope. There are more exciting projects on hand like sending mission to satellites of Mars, and perhaps even landing men on Mars. We also have a plethora of science fiction movies related to space such as: 2001—A Space Odyssey, Star Wars and Encounters of the Third Kind. But very few of us are aware that our Earth is also a spaceship, which is hurtling through space with tremendous speed.

First of all, let us answer the question: Why should we call the Earth a spaceship? A survey of the solar system reveals that there is no life anywhere in it, except on Earth. Mercury and Venus are too close to the Sun, which makes them excessively hot for the survival of life. Jupiter, Saturn and other outer planets, on the other hand, are so far away from the Sun that they are too cold to support life. Only Mars, with its clouds, polar ice caps, seasonal changes of colour and stormy winds, was suspected to be sufficiently similar to Earth, and hence, capable of providing conditions congenial for the existence of life. But, lack of oxygen and free water has precluded development of life on that planet also, which became evident from the Viking missions. Thus, our Earth is the only known abode of life within a radius of six light-hours from the Sun.

A consideration about the possibility of the existence of life elsewhere in the Milky Way indicates that there might exist advanced civilizations like ours on planets moving around some 100,000 stars in our galaxy. The average distance between any two such civilizations would be 500 to 1,000 light-years. Projects like OZMA, SETI and CYCLOPS are aiming at establishing contact with at least one of them. However, so far there has been no success and we are, at present, moving alone through the unbounded space without a companion. Hence, it is appropriate to call our Earth a spaceship. Let us, therefore, consider the trajectory, construction, problems and other aspects of our spaceship.

Earth’s rotation

A spaceship is stabilized by giving it a spin. Our Earth is also spin-stabilized, because it is spinning at the rate of one rotation per sidereal day, which is manifested by the daily rising and setting of the celestial bodies. As early as 500 AD, the Indian astronomer Aryabhata had argued as follows. Just as a man, travelling in a boat over a river, sees the objects on the banks receding backwards, so also, as we are carried from west to east by the Earth’s rotation, the celestial objects appear to rise in the east, traverse the sky from east to west and then set in the western horizon.

That the Earth is really rotating was proved by the French physicist Jean Bernard Léon Foucault in 1851 with his famous pendulum experiment. Now, it can be observed directly from a spacecraft like Apollo. In order to understand the Foucault pendulum experiment, let us go to the North Pole of the Earth. Once we reach there, all directions point to the south only. So we have to distinguish between them by designations like the Russian south, the Atlantic south, the American south, and the Pacific south, as shown in Fig. 1. Let us build on the North Pole a high rectangular tower ABCD, with glass walls. Let us suspend a pendulum bob from the ceiling, by means of a string. Let us pull the bob to one side and then leave it. It will be seen that the bob executes an oscillatory motion in a plane. If this plane were originally in the Russian-American axis, it will appear to rotate slowly clockwise, reaching the Atlantic-Pacific axis after six hours. The plane of the pendulum will continue to rotate in this fashion, completing one full round in 24 hours.

However, if we were to perform the experiment during the six-month long polar night, we shall see that the plane of the pendulum is fixed with respect to the stars, which will be visible through the glass walls. Since the conserva-
tion of the angular momentum requires the plane of the pendulum to remain fixed, the stars on the celestial sphere are also fixed, and we conclude that it is the Earth that is rotating below the fixed plane of the pendulum, in the anticlockwise direction.

If the Foucault pendulum experiment is performed at a place having a geographical latitude \( \phi \), then the plane of the pendulum would appear to rotate with a speed of 15 sin \( \phi \) degrees per hour, making one full round in \( 24 / \sin \phi \) hours. For example, the period will be 48 hours at Chandigarh, and 100 hours in Madras. The apparent rotation of the plane of the pendulum is explained as the result of a fictitious Coriolis force, which arises when we consider motions in a rotating frame of reference, like the Earth. The wind systems on the terrestrial globe are controlled by this Coriolis force. In fact, gunshots and ballistic missiles will not reach their targets if Coriolis force is not taken into account.

The Earth’s speed of rotation is 1,600 kilometres per hour near the equator. A jumbo jet, travelling from east to west above the equator with a speed of 800 km/hour, cannot equal this speed. Hence for the traveller in the jet plane, the Sun will still appear to rise and set, but with an interval not equal this speed. Hence for the traveller in the jet plane, west above the equator with a speed of 800 km/hour, can’t reach their targets if Coriolis force is not taken into account.

The couple formed by \( G \) and \( G' \) tries to make the axis of the Earth’s rotation perpendicular to the ecliptic plane. This is opposite to what was happening in the case of the top. Hence, the Earth’s rotational axis precesses backwards; that is, form east to west, around the ecliptic poles. The speed of this precession is quite slow. It takes nearly 26,000 years to compete one round. Consequently, the nodes of the Earth’s orbit; that is, the equinoctical points where it crosses the equator, move backwards on the ecliptic with this speed (see DREAM 2047 Vol.7 No.2). It is this precessional motion, also known as anachalan, which makes the seasons slide backward with respect to the stars (nakshatras) at the rate of one Indian nakshatra in about 950 years. That is the reason why the Makara Sankraman, which used to occur on 22nd December during the Siddhant period, about 1,500 years ago, has now shifted to 14th of January. Thus, it no longer represents the beginning of Uttarayan. Similarly, the Uttarayanan occurred in the Vedanga Jyotish period when the Sun entered the Dhanishtha nakshtra, from which we conclude that the epoch of Vedanga Jyotish was about 1,200 B.C. Thus, the phenomenon of precession is an important and useful as-

**Search for extraterrestrial civilizations**

**CYCLOPS:** This an immense array of radio dishes that has been proposed as a means for detecting radio signals from extraterrestrial civilizations.

**OZMA:** The Ozma project was conceived by Frank Drake; it was named for the queen of the imaginary land of Oz—a faraway place populated by exotic beings. In this project Frank Drake used the 26-metre radio telescope at Green Bank, West Virginia, in an attempt to detect signals from other civilizations.

**SETI:** SETI is the abbreviation for ‘Search for Extraterrestrial Intelligence’. It includes any of many searches, already made or planned, for extraterrestrial civilizations. In the reaches neighbouring and more distant stars are studied, primarily using radio telescopes, for signals indicative of intelligent life.

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Astronomy

Astronomical method of dating ancient periods of history, just like the radioactive method of carbon dating used by the archeologists.

In addition to rotation, our spacecraft, the Earth, has another slow motion, which is related to the Moon. We know that the Moon completes one revolution around the Earth in 27.32 days, which, incidentally, is the reason for having 27 nakshatras along the path of the Moon, nearly one for each day. Actually, the Moon and the Earth move around their common centre of mass, which is known as the ‘barycentre’. It is situated at a point about 4,800 kilometres from the centre of the Earth, or 1,600 kilometres below its surface. The Earth rotates around this point with a speed of 45 km/hour, which is comparable to the speed of a car or a train, completing one revolution in 27.32 days. This is the barycentric motion of the Earth.

Earth’s revolution

It is quite well known that the Earth and the Moon together revolve around the Sun completing one circuit in one year. The proof of the Earth’s revolution came in the year 1727, when the English astronomer James Bradley discovered the phenomenon of the aberration of starlight, which can be understood as follows.

It is a common experience that, if we walk in the rain and the raindrops are falling vertically downwards, we have to tilt our umbrella in the direction of our motion so that our feet do not get wet, as shown in Fig. 3 (a). The faster we move, the more we have to tilt our umbrella, because the angle of the tilt depends upon the ratio of our speed of walking to the speed of the falling raindrops. Now, when we look at a star through a telescope the umbrella is replaced by the objective lens of the telescope, and the raindrops are replaced by the photons of light. The only difference is that, while the umbrella tries to avoid the raindrops to keep our feet dry, the telescope objective captures the photons and brings them down to the eyepiece. Again, because of the motion of the Earth in its orbit, we have to tilt the telescope in the direction of the Earth’s motion, as shown in Fig. 3 (b). As the Earth revolves around the Sun, the telescope has to be turned in the changing direction of its motion, which causes the star image to trace an ellipse during the course of the year, as shown in Fig. 4. The ellipse becomes a circle in the case of stars near the ecliptic poles, while it degenerates into a straight line for stars in the plane of the ecliptic. This phenomenon is known as the ‘aberration’ of starlight.

The semi-major axis $a$ of the aberrational ellipse is equal to $v/c$ radians, where $v$ is the velocity of the Earth in its orbit and $c$ is the velocity of light. The value of $a$ is found to be $20".49 \times 10^{-5}$ radians for all stars, as the speed of light is $3 \times 10^8$ km/sec.

The high speed of the Earth, amounting to more than one million kilometres per hour, is so uniform and smooth that we do not feel it at all. Thus uniform motion and rest are indistinguishable for us. This reminds us of the Upanishadik statement about the Atman: ‘adejati; tannejati’ which means ‘It moves; it does not move’.

K.D. Abhayankar, Ishãyopanishad, 5.

Motions of the Sun

Actually, our spaceship Earth is moving with still greater speed, because the Sun is also moving in the general direction of the star Vega with a speed of 72,000 kilometres per hour. Consequently, our Earth and all the other planets, their satellites, asteroids and comets, which are a part of the solar system, are having a piggyback ride with the same speed.

The motion of the Sun among the neighbouring stars is observed as a reflected motion of approach and recession of the stars in the two opposite hemisphere of the sky. This is illustrated in Fig. 5. As the Sun moves towards A, the apex of the solar motion, with speed $v$, all stars appear to move in the opposite direction; that is, towards the antapex A’, also with speed $v$. The stars straight in the direction of apex A have the maximum velocity of
approach, which is seen as a Doppler shift of the spectral lines towards the shorter wavelengths, amounting to $\Delta \lambda = v\lambda/c$. Similarly, the stars straight in the direction of the antapex $A'$ have the maximum velocity of recession, which is seen as a Doppler shift of the spectral lines towards longer wavelengths, amounting to $\Delta \lambda = +v\lambda/c$. The stars in the perpendicular direction, namely those lying on the great circle $BB'$, do not show any velocity of approach or recession. But they have only transverse velocity. It is seen as an annual shift in their positions in the sky towards $A'$, which is called the ‘proper motion’. The stars in the intermediate positions show different velocities of approach and recession, as shown in Fig. 5.

Now, all the stars in the solar neighbourhood also move around the centre of the Milky Way. This is clearly shown by the Doppler shifts of the 21-centimeter line of hydrogen, observed by the radio astronomers in different directions of the Milky Way. All these stars, including the Sun, are moving in the direction of the Cygnus constellation. This motion is perpendicular to the line joining them to the centre of the Galaxy, which lies in the direction of the Sagittarius constellation. Their speed is 90,000 km per hour, and they complete one revolution around the galactic centre in 240 million years. This is accompanied by a small up-and-down motion, perpendicular to the plane of the Milky Way, with a period of about 60 to 70 million years. Our Sun and its retinue of planets, including the Earth, also share these motions.

### Movements of the Milky Way

Our galaxy is also not stationary; it is moving towards the Andromeda galaxy with a speed of 350,000 km per hour, due to the mutual attraction between them. But, if we look at the billion of galaxies that form the building blocks of the universe, they are found to recede from us. The speed of recession increases proportionately with distance, as found by Edwin Hubble. This has been interpreted as an expansion of the universe on the basis of the big bang theory of the origin of the universe. However, superposed on this smooth Hubble flow, each galaxy has a peculiar motion of its own caused by the local concentration of matter. In earlier days, scientists used to talk about the absolute motion of the Earth with respect to hypothetical all-pervading aether. But now we have to consider the motion of the observer with respect to the Hubble flow. It is given in Table 1, along with all the other motions of the Earth.

<table>
<thead>
<tr>
<th>Motion</th>
<th>Direction</th>
<th>Speed (km/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Rotation</td>
<td>West to East</td>
<td>1,600 (at equator)</td>
</tr>
<tr>
<td>2. Baryentric motion</td>
<td>West to East</td>
<td>45</td>
</tr>
<tr>
<td>3. Revolution</td>
<td>West to East</td>
<td>108,000</td>
</tr>
<tr>
<td>4. Solar motion</td>
<td>Towards Vega</td>
<td>72,000</td>
</tr>
<tr>
<td>5. Galactic rotation</td>
<td>Towards Cygnus</td>
<td>900,000</td>
</tr>
<tr>
<td>6. Milky Way</td>
<td>Towards Andromeda</td>
<td>350,000</td>
</tr>
</tbody>
</table>

### Earth’s makeup and history

Coming back to our spaceship, let us now consider its fabrication and internal structure. The spaceship Earth was created four-and-a-half billion years ago, along with the other planets from the remnants of the solar nebula, from which the Sun itself was formed only a few million years earlier. Although all the planets were formed from the same material, each of them has an individuality of its own. The proto-Earth, like the other rocky planets Mercury and Venus, had more dust than gas, and it was relatively hotter due to its closeness to the Sun. Consequently, the proportion of the light gases hydrogen and helium is negligible on Earth as compared to the Sun and Jupiter.

After formation, the Earth got heated up, partly by compacting and partly due to the release of energy by the radioactive elements in its interior. The interior melted and heavy elements like iron sank to the centre. The rotation of this liquid iron-nickel core produced a magnetic field and made the Earth a huge bipolar magnet. Radioactive energy is still being released in the outer envelope of the Earth, which causes convection and produces geological activity, including the continental drift. This is how the continents, oceans and the atmosphere of the Earth were formed. A unique scene among all the planets was thus set for the subsequent biological evolution on the Earth.

According to the present thinking, the atmosphere of the Earth originally contained only reducing gases like methane, ammonia and nitrogen. Electrical discharges in the atmosphere produced first proteins, then DNA and finally, living organisms of anaerobic nature. Later, with the advent of green plants, the oxygen content of the atmosphere started increasing and oxygen-
breathing animals came into existence. Mutations caused by the action of the ultraviolet and other energetic radiations, produced progressively more complicated life forms, culminating in the appearance of man, some one or two million years ago. The Dashavataras of the Hindu mythology trace this history of evolution in a crude form. The Avataras are in the order: Matsya (fish) living in water; Kurma (tortoise), an amphibian living both in water and on land; Varaha (boar), a mammal; Narasimha (man-lion), half-man and half-beast — say an ape; Vamana, a pigmy; etc.

Dangers to our spaceship

At first, humans developed slowly in his technical ability, and passed through a Stone Age, Iron Age, etc. His development has been phenomenal in the last three centuries since the advent of the Industrial Revolution. He is now able to comprehend the tiniest atoms on the one hand, and the vast universe on the other. He is also showing his innate capability and will power through feats like atomic explosion, green revolution, heart transplants, test-tube babies, computers, and space travel, etc. But, side by side with the scientific and technical progress, mankind is also facing new problems such as population explosion, energy crisis, environmental pollution and the fear of nuclear warfare. He is even beginning to wonder whether all this technological progress would ultimately lead to annihilation of not only mankind but also the precious life on our spaceship. However, the very idea of our Earth being a spaceship, with limited accommodation and resources, should make him wiser to such dangers. We hope that he would rather venture out into space to explore the almost unlimited universe instead of fight and destroy himself.

An ode to the mother Earth

Third in the row of planets,
Moves dear Earth, our life-giving mother.
By rotation it makes the day and night,
By revolution the seasons and the year.
It takes eight minutes and a third,
For the Sun-beams to reach our planetary nest;
In less than the seventh of a second,
The radio waves girdle its waist.

The iron magma, filled in the core,
Makes the sphere a bipolar magnet;
Obstructing the solar wind particles
Forms on high the Van Allen belt.

Covering the core is the silicate layer,
Which is heated by radioactivity.
It convects and moves the outer mantle,
And erupts through with volcanic fury.
Activity geologic, makes oceans and continents,
A moving picture of mountains and valleys,
Releasing the gases to cover the planet
With atmosphere, which scatters the blues.

With a host of living forms and species,
Evolution is crowned with man’s apparition.
Intelligent and skillful heir of Adam
Has worshipped the mother by perambulation.

As he moved in Sputniks in distant space,
And found no spot like his own abode,
Looking at the blue tinged crystal sphere,
His heart, with emotion, the vastness strode.

With the only natural satellite, the Moon,
Earth does form a planetary pair.
This beautiful site can only be seen
When man to descend on Mars does dare.

Leaving aside the man-made calamities discussed above, let us enquire whether there exist other hazards to our spaceship. In the solar system, we have a large number of objects, which include the Sun, the eight planets and their satellites, a few thousand asteroids and millions of comets. Is there any possibility that one of them would collide with the Earth and destroy it? Experts in celestial mechanics have studied this problem quite thoroughly. They find that the solar system is more or less stable, and there is little chance of any two major bodies colliding with each other. Hence we can be assured of our safety on this account. Collision of the Sun with another star is also ruled out on the basis of the calculations made by the Indian-born Nobel laureate S. Chandrashekhar.

However, there is another danger arising from the evolution of the Sun. Our Sun is at present producing its energy output by conversion of hydrogen into helium through thermonuclear reaction. Some five billion years from now, the hydrogen in its central part would be exhausted. As the temperature would not be sufficient to ignite helium for converting it into carbon, the core of the Sun would begin to contract and its envelope would expand. In other words, the Sun would become a red giant. When this happens the expanding Sun would devour our spaceship and all of us will be destroyed in that inferno. However, we need not worry about this very distant eventually at the present time. Let us hope that pretty soon mankind would be able establish colonies in other parts of the Milky Way.

Further Reading:


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In particle physics, meson is a boson with integral spin and composed of an even number of quarks and anti-quarks. The quark and anti-quark are bound together mainly by the strong force, and they orbit each other much as the Earth and Moon orbit each other. Because they must obey the laws of quantum mechanics, the quark and anti-quark can only orbit each other in a few specific ways, and each orbit corresponds to a different meson with different mass. Mesons vary widely in mass, ranging from 140MeV to nearly 10GeV. All mesons are unstable. Mesons serve as a useful tool for studying the properties and interactions of quarks, the fundamental units of matter that constitute all hadrons (any of the subatomic particles that react by the force of strong interaction). They also provide a means of identifying new quarks. The credit for the discovery of meson goes to a Japanese physicist and Nobel laureate, Hideki Yukawa.

Yukawa was born on 23 January 1907 in Tokyo, Japan. He was the third son of Takuji Ogawa and Koyuki Ogawa. His father was a professor of Geology at Kyoto University. In his childhood the houses of Kyoto were built in such a way that their inhabitants were isolated from the world outside. Later, Yukawa wrote that growing up in such a closed environment could foster rich imagination and a romantic temperament in a child. He graduated from Kyoto University in 1929 and became a lecturer there. In his students days often he spent entire days reading books, scientific magazines and journals without exchanging a single word with anyone. In 1933 he moved to the Osaka University and received his Ph.D. degree in 1938.

In 1939 Yukawa joined Kyoto University as a professor of theoretical physics and worked there till 1950. During 1950-53 he was at the Institute for Advanced Study in Princeton, New Jersey, USA and at Columbia University, New York. In 1953 he returned to Kyoto and became the Director of the Research Institute for Fundamental Physics in Takehara, which is renamed as Yukawa Institute for Theoretical Physics in his honour. Yukawa developed a non-local field theory for elementary particles. He specified how to get equations for non-local theory in a relativistic way and sketched how to obtain mass spectrum of elementary particles. Yukawa also predicted K-capture, in which a low-energy hydrogen electron could be absorbed by the nucleus. He introduced the famous Yukawa potential in his theory. He predicted the existence of the elementary particle meson and became the founder of the meson theory. He postulated that the short-range strong nuclear force was carried by a virtual particle now called the pi meson or pion. He also predicted in 1938 the intermediate vector boson, which mediates weak interaction.

Before Yukawa’s work the atomic nucleus was assumed to be made up of protons and neutrons. How these elementary particles were bounded within the nucleus remained a mystery. He started working on this problem from 1934 and often lay awake at night thinking about it. He used to keep a notebook at the side of his bed so that he could note down any thoughts he might have. Several ideas came to him but at the end they proved to be worthless. Interestingly, one night an insight came to him – there must be a relationship between the strength of the forces and the mass of the corresponding particles.

It is well known that the electromagnetic force between two electrically charged particles varies as $1/r^2$, where $r$ is the distance between the particles; it vanishes only when the particles are infinitely separated. The force arises from the charged particles exchanging photons between them. Reasoning along this line Yukawa worked out a theory of nuclear forces. Because protons alone could not form a stable nucleus since their mutual Coulombic repulsion would prohibit such a structure, he suggested that inside the nucleon there is a strong attractive force between protons and neutrons, operating over a very short range. He argued that this strong nucleon force is mediated by massive particles that are tossed back and forth between the nucleons.

Yukawa assumed that the exchanged particle must be something different from photon and introduced a coupling constant $G$. The values of $G$ and the mass of the exchanging particle should account the short range of nuclear force.
This led him to propose the so-called Yukawa potential $V(r) = -\frac{G}{r} \exp(-\mu r)/r$, where $r$ is the distance between the neutron and proton, $\mu$ is the rest mass of the particle and $G$ is a constant. The negative sign shows the force is attractive. As $\mu$ becomes larger and larger, the numerator becomes very small exponentially fast, for smaller and smaller values of $r$. Now $G$ and $\mu$ have to be adjusted to the range of $10^{-13}$ cm.

Using the experimental data Yukawa predicted that the mass of the new particle is about 200 times that of an electron but less than that of a proton. In 1935 Yukawa discovered the existence of a new particle with mass between that of an electron and a proton which was later called ‘meson’, which means ‘middle’ in Greek.

In 1935, while a lecturer at Osaka Imperial University, Yukawa presented his findings in a paper entitled ‘On the interaction of elementary particles’ (Proc. Phys. Math. Soc. Japan. Vol. 17, p. 48). His theory later became an important part of nuclear and high-energy physics and proved to be of great use in cosmic-ray research. His work had a major influence on research into elementary particles. An important outcome of his theory is that the nuclear forces can be traced back to an exchange of particles between nucleons.

It took another four years to identify the new particle discovered by Yukawa. In 1937 the American physicist Carl David Anderson discovered a new particle the mass of which was between that of an electron and proton and he called it ‘mesotron’. He then changed the name to ‘mesotron’, as suggested by the American physicist Robert Andrews Millikan. After his publication of the new particle, the Indian physicist Homi Jehangir Bhabha sent a paper to the journal Nature where he wished to call the new particle ‘meson’. He argued that ‘tr’ in mesotron is redundant because it does not belong to the Greek root meio for middle. But ‘tr’ in neutron and electron belong to the roots neutr and electr. Therefore, he suggested that the new particle be called ‘meson’. Bhabha described the interaction between two protons as well as two neutrons in terms of a charged meson. He showed that a positive or negative meson could change spontaneously into a positron or electron respectively, and a neutrino.

In 1947 the British physicist Cecil Frank Powell and his collaborators discovered Yukawa’s meson when they exposed nuclear emulsions to cosmic rays at high altitudes. The $\pi^+$ and the $\pi^0$ mesons were discovered with a mass of 140 MeV/c$^2$. The neutral pion $\pi^0$ was discovered later. Yukawa’s mesons could not be created in ordinary nuclear reactions but were generated when the interaction of nucleons produced sufficiently large amount of energy. Now they can be produced in a large cyclotron. The experimentally measured electric charge of mesons and their lifetime agreed with Yukawa’s prediction.

For his achievement Yukawa was awarded the Nobel Prize in Physics for the year 1949. He was the first Japanese to win the Nobel Prize. The prize came at a time when Japanese prestige was low and it provided tremendous encouragement to Japan’s young scientists. Yukawa, and Sin-Itiro Tomonaga, who got the Nobel Prize in Physics in 1965, were greatly responsible for establishing a strong school of theoretical physics in Japan.

Yukawa described himself as lonely, introverted and silent, especially as a child. He also worked for peace, particularly in the Pugwash movement. He married Sumiko Yukawa in 1932 and they had two sons Harumi and Takaaki.

Besides his purely scientific work Yukawa wrote many essays concerned with creativity and with the history and philosophy of science. He published many books including Introduction to Quantum Mechanics (1946) and Introduction to the Theory of Elementary Particles (1948). Both were written in Japanese. He started the journal Progress of Theoretical Physics and served as its editor since 1946.

Yukawa died on 8 September 1981 in Kyoto.

For further reading:


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Coronary Bypass Surgery
Creating wide new bridges over narrowed coronaries

A coronary bypass operation offers a new lease of healthier life to the owner of the diseased heart. During the surgery, narrowed sections of the coronary arteries are bypassed by using blood vessels taken from the chest wall and the leg. The new fuel lines restore blood flow to the heart and help prevent the symptoms of angina and the risk of a heart attack. First done in 1967, the surgery is now performed on a regular basis and hundreds of thousands of coronary patients across the world benefit from it each year.

Who might benefit
The decision of bypass surgery is usually based on the severity of symptoms, the state of coronary tree, and ventricular function. The ideal candidate is less than 75 years of age, has no other complicating disease, has troublesome or disabling symptoms that are not adequately controlled by medical therapy or does not tolerate medical therapy and wishes to lead a more active life, and has severe narrowing of several coronary arteries. Such patients may achieve considerable symptomatic benefit following the surgery.

The surgery is however not without risk. The risk is more if the heart’s left ventricular function is compromised (ejection fraction of less than 40%), if the age is more than 75 years, if diabetes is present, or if the surgery is done as an emergency.

Opinions whether the surgery helps extend the life span differ. In fact, results of several studies indicate that bypass surgery probably does not prolong life, unless the disease is severe and the patient has critical narrowing of the left main coronary artery or has three- or two-vessel disease with significant obstruction of the proximal left anterior descending coronary artery.

Preparation for the surgery
As is the case with any major chest surgery, it pays to keep your lungs in pink of health. If the surgery is elective and you have sufficient time, take the following steps.

Stop smoking: In fact, the thumb rule is: do not let anybody smoke in your presence.

Perform deep breathing exercises: The method is simple. Adopt a half sitting position. Place your hands over the upper part of abdomen, just between the angles of the rib cage. Breathe in deep through the nostrils. Next, let the air out slowly with your lips pursed as if you were blowing out a candle. Make sure your shoulders and upper chest remain still, and the hands resting between the angles of the ribs rise on inspiration and fall on expiration. This means you are using your lungs all the way down.

Cough out the lung secretions: Take a deep breath. Hold it. Now, quickly tighten your abdomen and cough the air out, instead of blowing it out. If you do it right, you would feel the stomach muscles contract under your hands. If you just clear your throat, as some people wrongly do, it will not help.

Medications: If you have diabetes, you shall be put on insulin. If you have high blood pressure, adequate measures shall be taken to control your blood pressure.

Surgery
On the previous evening, your body would be shaved, and you would be asked to take a shower. You would be given medication to relieve anxiety and asked to fast after midnight. In the morning, after ablution, you would be given a sedative shot. This shall make you drowsy. You would be shifted on a stretcher trolley to the operation theatre.

Once you are in the operating room, the anaesthesiologist shall stick an intravenous line into you, and he will use it to push the anaesthetic agent. You would immediately fall asleep. The surgery would take between two and four hours.

The surgeon might take two different approaches to access the heart: a midline incision over the chest, and split the breastbone (sternum); or through the left side of chest. The former approach is preferred if the plan is to perform an open-heart procedure, while the latter is generally taken for beating heart surgery.

Open-heart surgery
In most cases, a heart-lung machine is used to take over the function of the heart. The heart is bathed in a special solution and is stopped. This allows the surgeon the fix the new vessels with ease.

To bypass the obstructed sections of the coronary arteries, he has two alternatives: chip into the internal mammary artery, alter its course and direct it to feed the heart, or construct grafts from the vein drawn from the patient’s leg and fix them at one end with the aorta and on the other, beyond the obstructed portion of the blocked coronary arteries. As many grafts as necessary may thus be placed. The heart receives a fresh source of blood supply and you are relieved of the symptoms.
Once this vital part is complete, the heart and lungs are fixed back into the active circulation, and the heart resumes its function. The two edges of the breastbone are wired together, and the tissues and the skin on the chest are stitched back.

**Beatting heart surgery**

The second procedure, a less invasive technique, is carried out on the beating heart. The surgeon fixes the grafts while the heart is still active. The procedure is also known as the off-pump surgery. It is quicker, and does not usually require blood transfusion.

**Post-operative course**

Following the surgery, you would be shifted to the Recovery Room, where a team of doctors, nurses, and other trained staff shall provide constant care and monitoring. You might stay in this high care set-up for the next 24 or 48 hours. Once the effects of anaesthesia and medication wear off, you would regain consciousness. However, you might still feel dazed. You would find yourself connected with several wires, tubes and machines. A bedside monitor would continuously monitor your electrocardiogram, heart rate, respiration, and blood oxygen levels. Being sensitive to any change in vital parameters, its warning system begins to beep if it detects any abnormalities. An arterial cannula (kind of tubing) is used to keep a tab on the blood pressure. It is also used to obtain samples of blood. Another cannula in the neck vein provides a continuous readout of the venous pressure.

You may also notice the chest drainage tubes. They remove the bloody fluid from the chest and are connected to vacuum containers placed at the bedside. These drains stay till 24 to 48 hours after surgery. Another tube, the urinary catheter, helps drain urine from the urinary bladder. It is placed into the bladder at the time of surgery. Towards the end of the surgery, the surgeon places two or more pacemaker wires on the surface of the heart. These wires are brought out and stitched to the skin of the chest, and are connected by a cable to a temporary pacemaker box. This standby pacemaker can be used for controlling irregularities of the heart rate and rhythm, were they to occur.

A breathing tube (endotracheal tube) is placed inside the windpipe. It helps you breathe and is connected to a respirator, which moves air in and out of the lungs. The respirator is disconnected once you start breathing on your own. The breathing tube is removed a little later, usually 16 to 24 hours after surgery. As long as the breathing tube is there, it is not possible to talk, eat, or drink. When it is removed, you might at first feel a little sore in the throat and complain of hoarseness in voice. These effects shall soon wear off. Yet some discomfort is felt. You might also experience mental confusion and encounter weird dreams. These effects are transitory and should not cause concern.

You might still be using an oxygen mask. Intravenous fluids would fulfill your nourishment needs. You would be transferred to the intensive care unit for the next few hours, and if all goes well, soon be moved to the regular post-operative room. Most of the tubes are out and you are allowed to sit, stand and walk. You should make an effort to continue the deep breathing exercise. You might experience emotional instability—depression, anger, or frustration. It is transitory and it helps to keep one’s chin up. By day seven, you are ready to go home.

**Return to normal life**

You can resume normal activities before long. A moderation of activity and rest is best during the period of convalescence. Initially, getting out of the bed, taking a bath, and dressing yourself may also seem tiring, but as the days pass, things begin to look up.

You must take special care of the incision site. Keep it clean. Wash it gently with soap and water. Report to the surgeon if any redness, swelling, or discharge occurs. The leg incision takes a little longer to heal as compared to chest incision. You may also see a slight swelling in your ankle. Do not cross your legs. While sitting, keep your legs straight and propped up. Walking is also a good exercise to ease the swelling.

You can gradually resume simple, no-strain activities, such as helping your spouse in laying or clearing the table, or watering the plants. However, you should avoid moving, lifting, pulling or pushing items weighing more than five kilos, or vacuuming the house until the next few weeks while the breastbone heals.

You would be asked to pay a return visit to the hospital, usually one or two weeks from the date of release. Now, you would be under the care of a cardiologist, who would monitor your progress, ask for tests to gauge the improvement, and offer you advice about physical activity, medication, and lifestyle.

Sleep a good eight hours at night. A short 15-minute afternoon siesta would be good. You may also dine out, go for a movie, or visit friends and family. At about this time, normal sexual activity can also be resumed. A good measure of this is if you can walk three blocks briskly without being tired or short of breath, it is okay. You could also soon resume work.

**Results**

The operation is relatively safe, with mortality rates less than one per cent in patients without serious co-morbid disease and normal left ventricular function, when the procedure is performed by an experienced surgical team. Angina is abolished or greatly reduced in approximately 90 per cent of patients following complete revascularization. Within three years however, angina recurs in about one-fourth of patients but is rarely severe. The outcome is considerably improved if meticulous care is taken to check the coronary risk factors. A healthy lifestyle is essential for the maintenance of the newly established lifelines to the heart.
Earthquake Tip 9
How to Make Buildings Ductile for Good Seismic Performance

Construction Materials

In India, most non-urban buildings are made in masonry. In the plains, masonry is generally made of burnt clay bricks and cement mortar. However, in hilly areas, stone masonry with mud mortar is more prevalent; but, in recent times, it is being replaced with cement mortar. Masonry can carry loads that cause ‘compression’ (i.e., pressing together), but can hardly take load that causes ‘tension’ (i.e., pulling apart) (Figure 1).

Concrete is another material that has been popularly used in building construction particularly over the last four decades. Cement concrete is made of crushed stone pieces (called ‘aggregate’), sand, cement and water mixed in appropriate proportions. Concrete is much stronger than masonry under ‘compressive’ loads, but again its behaviour under tension is poor. The properties of concrete critically depend on the amount of water used in making concrete; too much and too little water, both can cause havoc. In general, both masonry and concrete are brittle, and fail suddenly.

Steel is used in masonry and concrete buildings as reinforcement bars of diameter ranging from 6mm to 40mm. Reinforcing steel can carry both tensile and compressive loads. Moreover, steel is a ductile material. This important property of ductility enables steel bars to undergo large elongation before breaking.

Concrete is used in buildings along with steel reinforcement bars. This composite material is called ‘reinforced cement concrete’ or simply ‘reinforced concrete’ (RC). The amount and location of steel in a member should be such that the failure of the member is by steel reaching its strength in tension before concrete reaches its strength in compression. This type of failure is ‘ductile failure’, and hence is preferred over a failure where concrete fails first in compression. Therefore, contrary to common thinking, providing too much steel in RC buildings can be harmful!

Capacity Design Concept

Let us take two bars of same length and cross-sectional area - one made of a ductile material and another of a brittle material. Now, pull these two bars until they break!! You will notice that the ductile bar elongates by a large amount before it breaks, while the brittle bar breaks sud-

![Figure 1](image1.png)

**Figure 1:** Masonry is strong in compression but weak in tension.

![Figure 2](image2.png)

**Figure 2:** Tension Test on Materials – ductile versus brittle materials.
denly on reaching its maximum strength at a relatively small elongation (Figure 2). Amongst the materials used in building construction, steel is ductile, while masonry and concrete are brittle.

Now, let us make a chain with links made of brittle and ductile materials (Figure 3). Each of these links will fail just like the bars shown in Figure 2. Now, hold the last link at either end of the chain and apply a force $F$. Since the same force $F$ is being transferred through all the links, the force in each link is the same, i.e., $F$. As more and more force is applied, eventually the chain will break when the weakest link in it breaks. If the ductile link is the weak one (i.e., its capacity to take load is less), then the chain will show large final elongation. Instead, if the brittle link is the weak one, then the chain will fail suddenly and show small final elongation. Therefore, if we want to have such a ductile chain, we have to make the ductile link to be the weakest link.

**Earthquake-Resistant Design of Buildings**

Buildings should be designed like the ductile chain. For example, consider the common urban residential apartment construction - multistoried building made of reinforced concrete. It consists of horizontal and vertical members, namely ‘beams’ and ‘columns’. The seismic inertia forces generated at its floor levels are transferred through the various beams and columns to the ground. The correct building components need to be made ductile. The failure of a column can affect the stability of the whole building, but the failure of a beam causes localized effect. Therefore, it is better to make beams to be the ductile weak links than columns. This method of designing RC buildings is called the ‘strong-column weak-beam’ design method (Figure 4).

By using the routine design codes (meant for design against non-earthquake effects), designers may not be able to achieve a ductile structure. Special design provisions are required to help designers improve the ductility of the structure. Such provisions are usually put together in the form of a special ‘seismic’ design code, e.g., IS:13920-1993 for RC structures. These codes also ensure that adequate ductility is provided in the members where damage is expected.

**Quality Control in Construction**

The capacity design concept in earthquake-resistant design of buildings will fail if the strengths of the brittle links fall below their minimum assured values. The strength of brittle construction materials, like masonry and concrete, is highly sensitive to the quality of construction materials, workmanship, supervision, and construction methods. Similarly, special care is needed in construction to ensure that the elements meant to be ductile are indeed provided with features that give adequate ductility. Thus, strict adherence to prescribed standards of construction materials and construction processes is essential in assuring an earthquake-resistant building. Regular testing of construction materials at qualified laboratories (at site or away), periodic training of workmen at professional training houses, and on-site evaluation of the technical work are elements of good quality control.

**Resource Material**


**Acknowledgement**:

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Sky Map for March 2007

Tips for watching the night sky:
1. Choose a place away from city lights/street light.
2. Hold the sky-map overhead with North in the direction of Polaris.
3. Use a pencil torch for reading the sky map.
4. Try to identify constellations as shown in the map one by one.

Planet Round up:
- **Saturn:** In the constellation Leo (Simha Rashi) near zenith.

Prominent Constellations: Given below are prominent constellations with brightest star therein (in the parenthesis). Also given are their Indian names.

Eastern Sky: Bootes (Arcturus) / Bhootap (Swati), Carvos, Coma Berenices, Crater, Hydra (Alpher) / Washuki, Virgo (Spice) / Kanya Rashi (Chitra).

Western Sky: Aries (Hamal) / Mesh Rashi, Lepus / Shashak, Perseus (Algod) / Yayati, Taurus (Aldebran) / Vrishabh Rashi (Rohini), Triangulum.

Southern Sky: Antila, Caelum, Canis Major (Sirius) / Bruhalubbdhak (Vayath), Carina (Canaopus) / Naukatal (Agashya), Columba, Puppis, Pyxis, Camloperdalis, Cassiopea (Schedar) / Sharmishtha, Ursa Major (Merak, Dhube) / Saptrishi (Pulah, Kratu), Ursa Minor (Polors) / Dhurbmatshya (Dhruvatara).

Zenith Sky: Auriga (Capella) / Sarathi (Brahmrday), Cancer / Kark Rashi, Canis Minor (Procyon) / Laghubbdhak, Gemini (Caster, Pollux) / Mithun Rashi, Leo (Regulus) / Simha Rashi (Magha), Lynx, Monocerus, Orion (Rigel, Betalgeuse) / Mriga (Rajanya, Ardra).

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The sky map is prepared for viewers in Nagpur (21.09°N, 79.09°E). It includes bright constellations and planets. For viewers south of Nagpur, constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Similarly, for viewers north of Nagpur, constellations of northern sky will appear higher up in the sky, and those of the southern sky will appear nearer the southern horizon. The map can be used at 10 PM on 1 March, at 9 PM on 15 March and at 8 PM on 31 March.
Indian Space Capsule Recovered

Indian space scientists attained a major success in their effort to develop a reusable space vehicle with the safe return of the capsule, SRE-1, earlier launched by Polar Satellite Launch Vehicle (PSLV-D7). Before India, only three other countries – Russia, the USA, and China – had achieved the feat of launching and retrieving a probe from orbit. After launch, the 550-kg capsule was placed in a circular polar orbit at an altitude of 637 km. It was one of the four payloads launched by PSLV-D7 from the Satish Dhawan Space Centre at Sriharikota, Andhra Pradesh on 10 January 2007. The capsule, returning after 12 days in Earth's orbit, survived a fiery re-entry into the atmosphere and parachuted down in the Bay of Bengal, about 140 kilometres from its launch site, from where it was picked up by a coast guard vessel to be ferried back to the Sriharikota.

The Space capsule Recovery Experiment (SRE-1) was intended to demonstrate the technology of an orbiting platform for performing experiments in microgravity conditions. It was also aimed at testing reusable thermal protection system, navigation, guidance and control, management of communication blackout, deceleration and floatation system, recovery operations, etc., required for successful return of an orbiting spacecraft. A team of 40 researchers of ISRO produced the lightweight heat-resistant tiles made from pure silica that lined the outside of the 550-kg capsule to protect it from heat during re-entry. But the present success is only one step towards future goals. Both reusable space vehicles and manned missions will also demand an array of other technologies such as new rocket engines, life-support and safety systems for astronauts.

Source: ISRO

Brightest Comet in 40 Years

Comets are visitors from the outer solar system that develop their showy tails as they approach the Sun. But, except for periodic comets, which return after definite, predicted intervals, their appearance is mostly unpredictable; most appear without any prior indication. As seen from Earth, comets are nebulous in appearance, and the tail is usually the most visually striking feature. This tail can in some cases stretch along a substantial arc in the sky. Some fainter comets, however, have little or no tail. The coma or head of a comet is seen as the ball of light from which the tail or tails emanate. Within the coma is the nucleus, the origin of the material in the tail and coma.

January 2007 saw one of the brightest comets in recent years. Astronomers and the general public had a rare opportunity to witness a bright comet more than a decade after Comet Hale-Bopp put up a great show in 1996. Named Comet McNaught after its Australian discoverer Robert H. McNaught, the new comet is a non-periodic comet. According to the International Comet Quarterly at the Harvard-Smithsonian Centre for Astrophysics, it is the brightest comet in 40 years after Comet Ikeya-Seki, which was seen in 1965. McNaught discovered it on 7 August 2006, but it became a naked-eye object only in early January 2007. It attained its greatest brightness on 13 January after perihelion on 12 January when it could be seen even in broad daylight. Being in an orbit that brought it very close to the Sun, Comet McNaught could be seen mostly during twilight hours. After perihelion the comet could be seen only from the southern hemisphere.

Source: www.spaceweather.com
Drugs from GM Chickens

Now eggs may become a source of life saving drugs. Scientists at Roslin Institute in Edinburgh, Scotland, have developed genetically modified (GM) chickens capable of laying eggs containing proteins needed to make cancer-fighting drugs. Helen Sang and her colleagues used a genus of viruses, called lentiviruses, which are characterized by a long incubation period and can be used to deliver a significant amount of genetic information into the DNA of the host cell. The scientists used these viruses to introduce genes into freshly fertilized chicken embryos. The inserted genes were found to trigger the production of various drugs rather than the protein ovalbumin, which normally makes up roughly 54 percent of egg whites. The GM cockerels born out of the genetically modified embryos were then screened for the new gene. Birds with the new gene were then bred with normal hens to produce a flock of chickens that carried the inserted gene and produced medicines in their egg whites.

Depending on the gene inserted in the cockerel embryo, the eggs laid by the new flock of GM hens produced either miR24 – a monoclonal antibody used in treating melanoma (a kind of skin cancer), or interferon b-1a – an immune system protein used to treat multiple sclerosis (a disease of the central nervous system), among other things. Some 15 to 50 micrograms of drug proteins was produced per millilitre of egg white and could be extracted and purified into therapeutic drugs.

According to the researchers, GM chicken eggs could be a route to faster, cheaper drugs than other genetically modified products such as goat milk that have been previously explored. Besides, chickens are easy to raise, produce numerous eggs, and are cheap to keep. After raising five generations of the modified birds, the researchers have observed no adverse health effects.


Synchrotron Accelerates Neutral Molecules

German physicists at the Fritz-Haber Institute, part of the Max Planck Society in Berlin, have developed a synchrotron that can accelerate neutral – rather than charged – particles. The device opens up the possibility of colliding neutral molecules at temperatures close to absolute zero. Synchrotrons are large circular devices in which charged particles are made to move near the speed of light round a ring using a combination of electric and magnetic fields. Ever since the first charged-particle synchrotrons were constructed in the 1940s, physicists have toyed with the idea of building a synchrotron that could accelerate neutral particles. In principle, some neutral molecules such as those of ammonia act as small electric dipoles that should be amenable to be accelerated in a synchrotron using a large electric field that switches at high speed. If a molecule is electrically polarized – meaning that positive charge tends to accumulate at one end and negative charge at the other – then it may feel a tiny tug toward places where the electric field is weakest. Unfortunately, the technology to do so was not available, and the idea lay dormant.

Physicists Gerard Meijer and Cynthia Heiner at the Fritz-Haber Institute have now overcome these difficulties and built a working neutral-particle synchrotron. Their device, which has a circumference of just 81 cm, is able to confine 3-mm packets of polar molecules such as ammonia over flight distances of more than 30 metres, at speeds of the order of 100 metres per second. The team has been operating the device at an extremely low temperature of just 0.5 degrees millikelvin (mK), at which point the molecules have such a low energy that they behave like waves. According to the researchers, the device could open a new avenue for the study of collisions between molecules, promising unique insights into their physical properties and chemical reactions. For example, electrons could tunnel through potential barriers, creating molecules that have never been witnessed before.

Source: Nature Physics, February 2007 (Advance online edition)

Polio: The Elusive Frontier

“monovalent” oral polio vaccine that targets only a single strain – Type1. Incidentally, the “monovalent” OPV containing only Type 1 polio (mOPV1) was found to be three times more effective than the tOPV, which is widely used in India. However, it would be a challenge to ensure that the virus does not return. It may, however, be emphasized that tOPV will continue to be used for most campaigns in endemic areas and for routine childhood immunization, while mOPV1 would be used as an adjunct to existing immunization activities. One can go back and hit Type 3 later.

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

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

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