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VP News

Dr. T. Ramasami takes over as Secretary, DST; and Chairman, Governing Body, VP

Dr. T. Ramasami

Prof. V. S. Ramamurthy

Professor V. S. Ramamurthy retired as Secretary, Department of Science and Technology on 30 April 2006, after a distinguished career. He was also Chairman, Governing Body of Vigyan Prasar. He inspired and guided several new activities in Vigyan Prasar.

Dr. T. Ramasami took over as Secretary, DST on 25 May 2006. Dr. Ramasami has been a distinguished technologist and has attained several recognitions in his academic and professional career. He is committed to the cause of science relating to technology, technology relating to manufacture, and manufacture relating to society. He was responsible for saving nearly 400 tanneries from closure through technology intervention while he was Director, Central Leather Research Institute, Chennai. He is a recipient of CSIR Special Technology Award (1998) and The Technology Award from the Third World Network of Scientific Organizations (1998). He has over 120 publications in journals of repute. Dr. Ramasami was awarded Padmashri for his outstanding contributions in the field of Science and Technology in the year 2001. Soon after taking over as Secretary, DST, he paid a visit to Vigyan Prasar and evinced a keen interest in its activities. Through his inspiration and guidance, Vigyan Prasar is bound to scale greater and greater heights, we are sure. Vigyan Prasar welcomes Dr. T. Ramasami as its new Chairman, Governing Body.

Dr. T. Ramasami, Secretary, DST (second from left), discussing programmes with VP Scientists

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... think scientifically, act scientifically... think scientifically, act scientifically... think scientifically, act...

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Editor : Dr. V.B. Kamble

Evolution – Can It Run Backwards?

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

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

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

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

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

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

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Pierre-Simon de Laplace

"Who was Second only to Isaac Newton"

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Known as the "Newton of France," Pierre-Simon de Laplace transformed the study of mathematical astronomy with his five-volume *Traite de mecanique celeste* (1799-1825). Using the language of calculus and differential equations, he expressed Newton's *Principia* in its modern language, solved many of the issues left open by his predecessor, and demonstrated the stability of the solar system.

Mario Bertolotti in *The Oxford Companion to the History of Modern Science*

Laplace was a brilliant and inspired mathematician, one of the most influential scientists of the 18th century. Although he is largely unknown by most people today, his rigorous mathematical work nailed down some of the loose ends left by Newton and provided a stronger foundation for the speculation of Kant.

The History of Science: In the Eighteenth Century by Ray Spangenburg and Diane K. Moser

Laplace is regarded as one of the most influential scientists of all time. He worked in the 18th century. His greatest work was the *Traite de mecanique celeste* (Treatise on Celestial Mechanics) published in five volumes between 1799 and 1825. In this five-volume work, Laplace presented his analytical discussion of the solar system. The first volume was divided in two parts, the first part contained general laws of equilibrium and motion of solids and also fluids, and the second part contained the law of universal gravitation and the motions of the centres of gravity of the bodies in the solar system. The second volume dealt with the mechanics required for calculating the motion of the planets, determining their figures, and resolving their tidal problems. The third and fourth volumes contained applications of these methods, and several astronomical tables. The fifth volume was mainly historical but it also included Laplace's recent researches. Laplace's *Treatise on Celestial Mechanics* not only expressed Newton's *Principia* in its modern language, in the language of the differential calculus, but it also completed parts of which Newton had been unable to fill in the details.

Pierre-Simon de Laplace

There is an interesting episode associated with this great work. It is said that Laplace entreated Napoleon to accept a copy of his *Celestial Mechanics*. Napoleon accepted Laplace's work with the remark, "M. Laplace, they tell me you have written this large book on the system of the universe, and have never even mentioned its Creator." Laplace was supposed to have replied, "Sir, I do not have need of that hypothesis." Apparently Napoleon was very much amused with Laplace's answer. When Napoleon mentioned this to Lagrange, the latter was said to have remarked, "Ah, but that is a fine hypothesis. It explains so many things." It was not very easy to follow Laplace's celestial mechanics. Laplace, while describing mathematical equations, often used the phrase 'it is obvious' but in reality it was far from obvious!

Besides his wok on celestial mechanics, Laplace worked on a number of problems in physics namely capillary action, double refraction, the velocity of sound, the theory of Earth, and the elastic fluids. Laplace established the probability theory on a rigorous basis. His researches on the probability theory were presented in two of his important works: *Theorie analytique des probabilities* (Analytic Theory of Probabilities, 1812) and *Essai philosophique sur les probabilities* (Philosophical Essay on Probabilities, 1814). He developed the concept of a 'potential' and he described it by an equation, now called Laplace equation. This concept found an enormous number of applications in all kinds of areas.

Laplace served in various committees constituted by the Paris Academy of Sciences. He was a member of the committee constituted for standardising weights and measure. The committee, which was constituted in May 1790, worked on the metric system and advocated a decimal base. It should be noted here that when the Reign of Terror in 1793 suspended all learned societies including the Paris Academy of Sciences, the Weights and Measures Commission was allowed to work. However, Laplace, Lavoisier, Borda, Coulomb, Brisson and Delambre were thrown out of the Commission. Perhaps Laplace saved his life by moving out of Paris; he had left Paris before the Reign of Terror commenced. Laplace also survived because he compromised with the ruling regime. As we know Lavoisier was guillotined in May 1794.

Laplace returned to Paris in July 1794 and lived some 50 kilometres southeast of Paris with his family. Laplace was a founder member of the Bureau des Longitudes established in 1795. He later became the head of the Bureau and the Paris Observatory. He was a member of a committee constituted for investigating the largest hospital in Paris. He used his expertise in probability to compare mortality rates at the hospital with those of other hospitals in France and in other countries.


Pierre Eugène Marcellin

We do not have much information about the early life of Laplace. There are no comments of those who knew him as a child. Laplace was born at Beaumont-en-Auge in Normandy, France on 23 March 1749. His father Pierre Laplace was in the cider business in which he did well. Laplace's mother Marie-Anne Sochon came from a prosperous farming family. In some accounts of Laplace's life it has been reported that he was born in a poor family but that is not true. Laplace was admitted into the Benedictine priory school in Beaumont-en-Auge at the age of seven and he remained in this school till he was 16. His father wanted him to enter the Church. He thus joined the Caen University to study theology. However, while studying theology, he became deeply interested in mathematics. In pursuing his interest in mathematics he was guided by two mathematics teachers at Caen, namely, C. Gadbled and P Le Canu.


Simeon-Denis Poisson

Laplace finally decided to devote himself to mathematical studies and not to theology. He left the Caen University without taking his degree and then he went to Paris. One of his mathematics teachers who encouraged him to take up mathematics as his vocation had given him a letter of introduction to d'Alembert. Describing Laplace's first interaction with d'Alembert, Ioan James wrote: "The story has often been told of how d'Alembert gave Laplace difficult mathematical problems to solve as a test of his ability: the young man was able to solve them overnight. Much impressed, d'Alembert used his influence to secure Laplace a position at the Ecole Militaire in Paris, teaching the cadets elementary mathematics. This lasted for the next seven."

Once he was settled in Paris, Laplace's immediate aim was to enter the Paris Academy of Sciences. It was not an easy task. Laplace started sending his research papers to the permanent Secretary of the Academy. He was first proposed for election in 1771. He could not be elected, the position went to Vandermonde. The next year his name was again proposed but this time also proved to be unsuccessful. This time Victor Cousin (1792-1867) was elected. Finally, in third time, he was elected as adjunct member of the Academy in March 1773. At the time of his election to the Academy he was 24. By the time of his election he had read 13 research papers on wide-ranging topics.


Victor Cousin

In 1773, Laplace demonstrated that gravitational perturbations of one planet by another would not lead to instabilities in their orbits and thereby he explained the long-term stability of the solar system. To prove his point he solved two theorems involving the mean distances and eccentricities of the planetary orbits. It may be noted here that contrary to Laplace, Newton held the belief that such disturbances, without divine intervention, would eventually disintegrate the solar system

Laplace proposed a hypothesis to explain the origin of the solar system. This was called the "nebular hypothesis". According to this hypothesis the formation of the Sun started with a giant rotating disc (or nebula) of gas. As the disc of the gas continued to rotate around an axis through its centre of mass and contract due to gravitational pull, its speed of rotation continued to increase and in this process a time came when the outermost material in the rotating disc moved too fast to be held by its gravitational force. The result was that the outermost material in the form of a ring separated from the main disc and later condensed to form a planet. The central disc continued its rotation with increasing speed and its contraction till it left more outermost gaseous material to form another planet. This process continued till all the planets were formed and central part of the rotating disc of gas formed the Sun. The satellites and rings of the respective planets formed in the similar process.


Jean-Baptiste Biot

Though Laplace's "nebular hypothesis" could not explain many features of the solar system, it became quite popular in the nineteenth century because it was an attempt to explain the formation of the solar system by using scientific reasoning and not taking the recourse of metaphysical reasoning. It may be noted that even before Laplace, Immanuel Kant (1724-1804) had suggested a similar idea about the formation of the solar system though in a less rigorous form. This is why the Laplace "nebular hypothesis" is also referred to as Kant-Laplace nebular hypothesis.

According to another theory, the origin of the solar system can be traced to the gradual aggregation of meteorites that swarm through our system and perhaps through our space. Meteorites are normally cold. However, with repeated collision they may be heated, melted or even vaporised. The resulting mass would condense due to gravitational force. The condensation and collision process continued till the planet-like bodies formed. This theory supposed that at a distant epoch a vast number of meteorites were situated in a spiral nebula and the condensations and collisions took place at certain knots or intersections of orbits. Present investigations have revealed the possibility that our Moon might have broken off from the Earth when the latter was in a plastic condition owing to tidal friction.

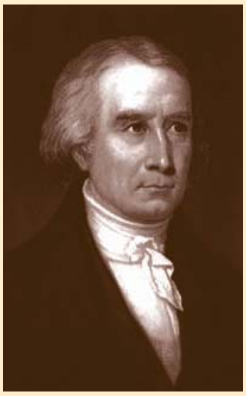
Laplace, jointly with Pierre Eugene Marcellin Berthollet (1827-1907), founded a scientific society called Societe d'Arcueil in around 1805. The Society operated out of their estates in Arceil situated south of Paris. The Society organised meetings of young scientists in 1806 with a view to encouraging them to pursue research in the Newtonian style. These meetings were organised under the aegis of Societe d'Arcueil. Those young scientists who attended these meetings became leaders of French science in the next generation. They included Jean-Baptiste Biot (1774-1862), Simeon-Denis Poisson (1781-1840), Dominique Francois Arago (1786-1853), Etiene Louis Malus (1775-1812), and Joseph Louis Gay-Lussac (1778-1850).

Etiene Louis Malus

Laplace collaborated with Antoine-Laurent Lavoisier on solving a number of scientific problems; the most important ones among them were the behaviour and nature of heat and the systematisation of the concepts and nomenclature of chemistry. For studying the nature of heat, Laplace had invented an ice calorimeter.

Laplace prospered during the reign of Napoleon Bonaparte. In 1799, Napoleon appointed Laplace as Minister of Interior. He remained in this post only for six weeks when he was replaced by Napoleon's brother Lucien Bonaparte. Napoleon was not at all impressed by Laplace's administrative abilities. Laplace became a member of the Emperor's Senate and he held the office of Chancellor. He was also made a Count by the Emperor. In 1814, he supported the restoration of Bourbon monarchy by voting against Napoleon in the Senate. He was rewarded by the new emperor Louis XVIII; Laplace was made a marquis.

Immanuel Kant



Dominique Francois Arago

Laplace's personal behaviours were far from satisfactory. After he attained his fame, he remained aloof from his relatives and benefactors, who helped him in his early age. He even ignored his parents and sister. His behaviour towards his friends was mean and ungrateful. He was a careerist and for his personal benefit he did not hesitate to desert his old friends or mentors. He was very arrogant towards his fellow academicians and junior colleagues. His arrogance increased with his age. He would give his opinion on every conceivable subject. And as someone commented, he hardly listened to anyone but himself. This attitude of Laplace made him unpopular among his fellow academicians. Laplace was also accused as plagiariser for genuine reasons. He appropriated from earlier works with inadequate or no acknowledgement. This was unfortunate particularly when his own contributions were so numerous and valuable. In spite of having all these negative personal traits he supported young talents to pursue science.

Joseph Louis Gay-Lussac

Laplace died on 5 March 1827. It is said that before he died he uttered these last words: "What we know is very slight; and what we do not know is immense." The French Academy of Sciences, cancelled its businesses on the day Laplace died. It was a rare show of respect to one of the greatest scientists of the 18th century. Laplace eminently deserved the honour bestowed upon him. *The Cambridge Dictionary of Scientists* writes: "In the fields in which Laplace worked and where Newton worked previously, he is seen as second only to Newton in his talent."

References

1. Spangenburg, Ray and Moser, Diane K. *The History of Science: From the Ancient Greeks to the Scientific Revolution,* Universities Press (India) Limited, 1999.
2. James, Ioan. *Remarkable Mathematicians: From Euler to von Neumann*, Cambridge University Press, 2002.
3. *The Cambridge Dictionary of Scientists* (second Edition), Cambridge University Press, 2003.
4. *A Dictionary of Scientists*, Oxford University Press, 1999.
5. *Chambers Biographical Dictionary* (Centenary Edition), Chambers Harrap Publishers Ltd, 1997.
6. Rao, Indumati and Rao, C.N.R. *Learning Science Part I: Universe, Solar System, Earth,* Jawaharlal Nehru Centre for Advanced Scientific Research, 2005.
7. *The Macmillan Encyclopedia*, Macmillan London Ltd., 1981.
8. Available resources on the Internet.

Mysteries of the Infinite

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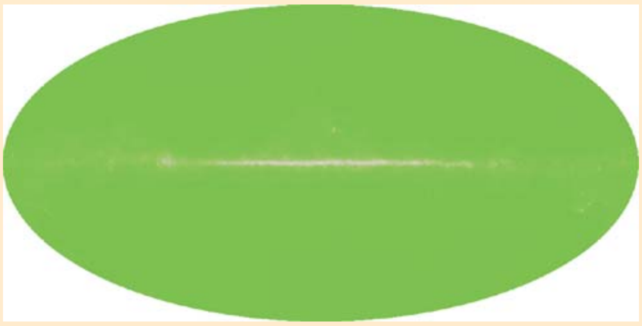
Prologue

14 billion years ago there were no air, no Earth, no sky, no Sun, no stars, no galaxies, no matter, and not even light. The universe was a highly dense and infinitesimally small lump. Suddenly, there was a huge explosion – the "Big Bang". And there was light! It was an intensely hot soup of entangled light and elementary matter that filled the space. That was the beginning – the beginning of matter, the beginning of light and the time!

The universe went on expanding and grew in size at a maddening speed and then slowed down a bit. Four hundred thousand years later, this hot primordial soup turned much cooler and thinner. The universe had by then expanded to barely one-thousandth its present size; the primordial soup separated into matter and light. For the first time photons of light could travel freely in space, to large distances, without encountering any matter, and our visible universe came into existence.



Cosmic microwave sky as seen by Wilson and Penzias in 1964. The central white band is the foreground radiation by our own Milky Way. Image courtesy: NASA/WMAP Science Team

Let us now travel far – far ahead in time. The German-born American physicists Arno Penzias and American radio astronomer Robert Wilson were two researchers in AT&T, Bell Laboratories in USA. In 1964, they were trying to develop a dependable and noise-free trans-Atlantic microwave radio communication system. But, there was a mysterious background noise in their radio antenna. Day and night, the noise was present all the time. And it appeared to come uniformly from every direction in the sky. That was an accidental but absolutely path-breaking discovery. Wilson and Penzias had stumbled upon the relics of the earliest radiation of the universe that was left behind just after the hot and explosive beginning. That was the virtual proof that the Big Bang had actually occurred.

We are all made of star stuff

Especially since the last quarter of a century we have been witnessing a technological revolution on Earth. Vastly empowered by this, human kind has entered into a virtual exploration spree, be it in the depths of oceans, on other planets, or in the depths of the vast universe – even beyond the realm of stars. Until a few years ago, we had just one telescope in space; now we have four! Quite a few large ground-based new-technology telescopes are also aiding us in our efforts of breaking new grounds.

The sky hides much more beyond those starry patterns. But usually, these are so far away and so faint that we can't see them with just the naked eyes; a pair of binoculars or a telescope helps to see them. Point a telescope towards the constellation Virgo and a teeming cluster of galaxies will greet you. Faint as the cluster members may be, they are strewn over this region like a wild growth of flowers across a meadow. There are thousands of millions of such clusters spread all across the sky; some are more compact with more galaxies in them and others are as sparse as the Virgo Cluster.

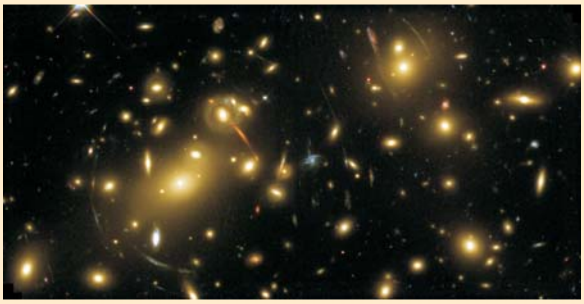
In the words of German philosopher Immanuel Kant these are 'Island Universes' in their own right. Billions and billions of stars and also huge clouds of dust and gas make up each one of these. Sometimes hundreds of light years across, these huge clouds of gas and dust are the nurseries of new generation stars – we call them nebulae! Deep within, the "wombs" of these nebulae young stars get ready to take birth. Once born, a typical Sun-like star with a burning furnace of nuclear hydrogen in its core would shine for 10 billion years; a star half as massive is much more prudent in burning its fuel and will keep shining for double the time. There are giant stars too – 10 times more massive than the Sun. These super-massive stars blaze away quite rapidly. Their nuclear hydrogen stocks go bust in just about 20 million years. Soon enough, they end up in brilliant cosmic fireworks. In their death, the massive stars enrich their surroundings with new elements; these were once cooked inside the stellar nuclear furnaces. Oxygen, carbon, nitrogen, iron, nickel, silicon – any element you name – they were all once cooked inside the stars. We owe our existence to these early generation stars.

Star tour

To explore the universe around us, let us venture into an imaginary voyage through space. Imagine, far away from the solar system, we are in the realm of stars. About a hundred thousand years through these stars, and we are finally out of our own galaxy. The Sun is lost

Spiral galaxy M74, as seen from top. Our own Milky Way has a similar structure.

in a crowd of a hundred billion stars in a giant flat spinning wheel. Look at those delicately curved fluffy arms around the disk. Our next-door galactic neighbour – the Andromeda galaxy is still two million years away even at the speed of light. Let us move ahead in our journey. After several hundred million years the Milky Way disappears into the empty blackness. We are approaching a huge group of hundreds of galaxies. Remember the constellation Virgo back home at Earth? We are presently heading in that direction. The famous Virgo Cluster lies just ahead of us.

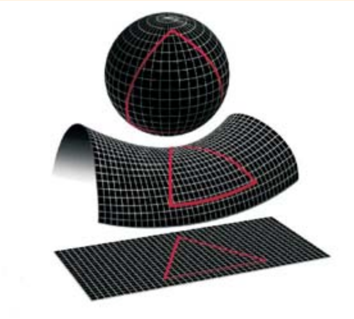


Massive galaxy cluster Abell 2218 – a cosmic magnifying glass. This 'hefty' cluster resides in the constellation Draco, some two billion light-years from Earth. Image courtesy: NASA, ESA, Andrew Fruchter (STScI), and the ERO team.

From smaller scales to a larger one this is what the universe looks like. Stars are not scattered uniformly through space; they are grouped into galaxies – several hundred billion stars goes in to making a galaxy like our own. Even galaxies are not sprinkled randomly across vast space. A large percentage of these galaxies are grouped into clusters – several million light years across.

The birth of modern cosmology

Our quest towards comprehending the framework of universe received tremendous boosts by three major developments. The first one took place in 1916, as Albert Einstein developed his famous General Theory of Relativity. Einstein's theory presents gravitational force field in a totally new perspective. According to his theory – matter tells space how to curve, and space, in turn, tells matter how to move. Assuming that matter in the universe is distributed uniformly on the largest scales, space may get curved in any of the three ways in presence of matter. It can be "positively" curved like the surface of a ball and be finite in extent; it can be "negatively" curved like a saddle and be infinite in extent; or, it can be "flat" and can again be infinite in extent. In a finite universe you can start a journey off in one direction, and if allowed enough time, you can ultimately return back to your starting point. In an infinite universe you would never return.



Examples of positively curved (top), negatively curved (middle), and flat (bottom) surfaces

The second significant development took place in 1929. For years, the American astronomers Edwin Hubble and Milton Humason were surveying the distances of nearby galaxies. They found lights from distant galaxies have special signatures implanted in them. Light waves, in most cases, are stretched and appear a little reddish as they travel through space. These are the signatures of tremendous speeds with which these galaxies appear to be flying away from us. Faster the speed stronger is the stretching. Hubble and Humason compared the distances of these galaxies and their speeds. They found, the farther the galaxies are, proportionately faster these are moving away. Hubble had not only discovered that outside our galaxy there is an entire universe waiting for us to explore, but that the universe was expanding. The proportionality factor between speed and distance is now famously known as the 'Hubble Constant'. It measures the universe's expansion rate. It also reckons that the entire universe was contained in a very small volume in a distant past. There was an explosive beginning and it has been expanding since then.

Distances between galaxies or even the stars are nowhere near earthly standards; these are huge and truly mind-boggling. Astronomers find it equally tricky when it comes to determining vast cosmic distances with precision. Light rays from nearby stars take years to reach us; for the distant galaxies this time-scale easily stretches to billions of years. When we look at them we see the universe frozen in time; they appear to us as they were millions or billions of years ago. For that matter, a 'light year' comes in quite handy while describing huge cosmic distances.

But how do we measure astronomical distances? Astronomers solve this distance puzzle through a waiting game. When one of the billions of stars in a host galaxy explodes into a supernova, they quickly grab the opportunity to estimate distance. This sudden brightening is momentary – from a few days to a few months at best. Nevertheless, a supernova is very bright – bright enough to be visible across extremely large distances. Standard peak brightness of a rare supernova provides the vital clue in solving the distance puzzle.

The Hubble Space Telescope and other large observatories around the world are especially adept in detecting distant supernovae almost up to the edge of the universe. Dedicated to the memory of Edwin Hubble and his path breaking contribution, the Space Telescope's one primary goal is to help determine the exact value of Hubble Constant through accurate measurement of cosmic distances. Exact value of this constant is important; it sets the scale of the universe – the time back to the big bang and its size.

The most recent value of the constant indicates the universe is just 9 billion years old. On the contrary, the oldest surviving stars indicate the universe is anything above 12 billion years old. How can that be? Surely, a mother can't be younger than her child! Possibly, there is something seriously wrong in our understanding of the universe!

Is that all what meets the eyes?

In our quest for answers let's look up towards they sky once again. Remember, the galaxies almost always appear in clusters! Let us have a look at one such cluster. Mark those giant circulars arcs in the cluster. These arcs are practically images of background galaxies many times farther out. Ordinarily, we should not be seeing them; the cluster obstructs our view. Thanks to the gravitational-lensing effect. The massive cluster's, colossal gravity field plays often as a disfigured lens – bending, and focussing the light rays into distorted images.

Gravitationally lensed images are of extreme interest for cosmologists. From these images they can precisely tell the entire mass involved in lensing clusters. Unbelievably, most of the mass involved in the lensing is not visible to us at all! Cosmologists have stumbled upon a hitherto unknown form of matter. Though we can't see it, we can make out its presence the way it bends light – by its gravity. Even more surprisingly, this so-called 'dark matter' is many times more abundant in the universe than the visible ordinary matter. We are made of star stuff for sure, but apparently, most of the universe is not!

What makes up the universe then? The mass of ordinary matter is mostly made of neutrons and protons – collectively known as baryons; they emit light or, glow or, scatter or, sometimes even absorb light; dark matter is not made of these. Dark matter has no baryons. No one has ever come across such a thing here on Earth!

Astronomers have been carrying out a census of galaxies in the universe for many years. They have produced maps showing how the galaxies are spread across space. Each small dot in this image represents a galaxy. Over large distances galaxies show a discrete tendency; they group up and prefer to stay in clumps. There are groups of groups – called clusters, and even clusters of clusters – called 'superclusters'. At extremely large scales, of about a billion light years, the superclusters are organised in a web of structures – lines, filaments, flakes or sometime even walls! Particular concentrations of galaxies appear at each intersection of these filaments. In between the filamentary distribution are vast regions, practically devoid of any galaxy. Apparently, galaxies and clusters are strewn along boundaries of these bubbles of voids or empty space.

Theoretical and cosmological impact of this discovery is immense. Structures as vast as superclusters and voids mirror the original distribution of matter just after the creation in Big Bang. These structures can therefore tell us about processes that form galaxies, which are still not clearly understood.

Cosmic Background Radiation reveals it all

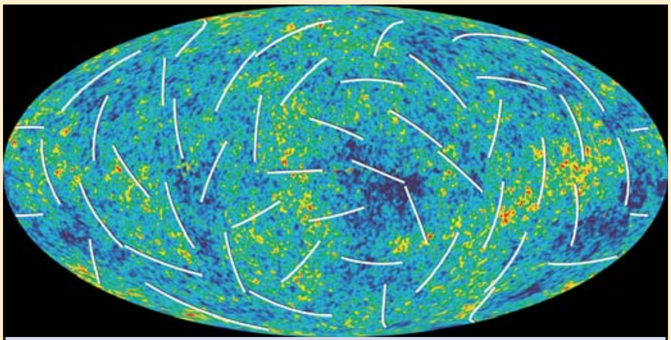
Discovery of cosmic microwave background radiation in 1964 by Wilson and Penzias was the third major development that changed the course of cosmology forever. The ubiquity and constancy of cosmic background radiation is a sign that it comes from a simpler past, long before the structures of superclusters, galaxies and planets evolved. Because of this simplicity, we can predict the properties of this radiation with exquisite accuracy. And in the past few years cosmologists have been able to compare these predictions with increasingly precise observations from microwave telescopes carried by balloons and spacecraft.

The Cosmic Background Explorer (COBE) satellite went up into an orbit around Earth in 1989. It could 'see' in the radiation emitted by the early universe. Expansion of universe has stretched and red shifted this radiation from the earliest times into the microwave part of the spectrum beyond visible wavelengths.

The microwave sky discovered by Wilson and Penzias was totally bland, except of course, along the plane of our home galaxy, the Milky Way. But above and below this plane there were no variations in the microwave background radiation. COBE could detect ever so slight variations in the otherwise bland microwave background radiation. The minute variations – about one part in one hundred thousand, are variations in the temperature in the early universe – just about four hundred thousand years after the Big Bang. As recently as in 2001, through a new satellite observation cosmologists have been able to map the entire microwave sky in much more detail and at 100 times the sensitivity of COBE. It could find extremely tiny fluctuations representing the slight clumping of material in the infant universe. Over billions of years these clumps condensed, as gravity pulled in more and more matter from the surroundings and gave rise to the galaxies; groups of nearby galaxies formed web of structures. The seeds planted in the infant universe evolved, with time, into billions and billions of galaxies that we see today. Among other things satellite observations have confirmed the presence of dark matter and something even more bizarre.

Most of the universe is no star stuff

As you throw a ball up, it gradually slows down, halts, and then, starts coming down. This is all because of gravity. Similarly, all the matter making up the universe pulls it inward – arresting the expansion. For many decades astronomers have been toiling hard; they are thrusting their telescopes to their limits, to penetrate deep into the universe, searching for an evidence of this slowing-down. By measuring this slow-down rate they also hope to learn about its destiny. Would the universe halt at some point of time? Would the expansion reverse and would the universe re-collapse?



Wilkinson Microwave Anisotropy Probe (WMAP) is a NASA explorer mission measuring the temperature of the cosmic background radiation over the full sky with unprecedented accuracy.

WMAP has produced a new, more detailed picture of the infant universe. Colors indicate "warmer" (red) and "cooler" (blue) spots. The white bars show the "polarization" direction of the oldest light. This new information helps to pinpoint when the first stars formed and provides new clues about events that transpired in the first trillionth of a second of the universe.

The expansion of the universe over most of its history has been relatively gradual. The notion that a rapid period "inflation" preceded the Big Bang expansion was first put forth 25 years ago. The new WMAP observations favor specific inflation scenarios over other long held ideas.

In 1998, two groups of physicists from USA and Australia lead by Saul Perlmutter and Brian Schmidt were looking for distant extra-galactic supernovae whose lights left their host galaxies billions of years ago. They were hoping to determine the slow-down rate of universe's expansion. Curiously enough, these distant supernovae didn't appear as bright to them as they expected – they were fainter. The most plausible explanation is that the light from the supernovae travelled a far greater distance than expected. These observations point to only one conclusion – the universe's expansion is actually speeding up, instead of slowing down!

Hubble Space Telescope Image of Supernova 1994D in Galaxy NGC4526. Image courtesy: ESA

In 2001, the Hubble Space Telescope had almost accidentally chanced upon an extremely distant supernova. The red shift of light from this stellar explosion told us that it took place 10 billion years ago, when the universe was just one-third its current size. This time the object appeared much brighter than expected. This result was the first direct evidence of an epoch when the universe's expansion was actually slowing down. In fact, astronomers have found that the speeding up of expansion is recent. During much of its 13.7 billion years of history the universe was slowing down; it started speeding up only about 5 billion years ago.

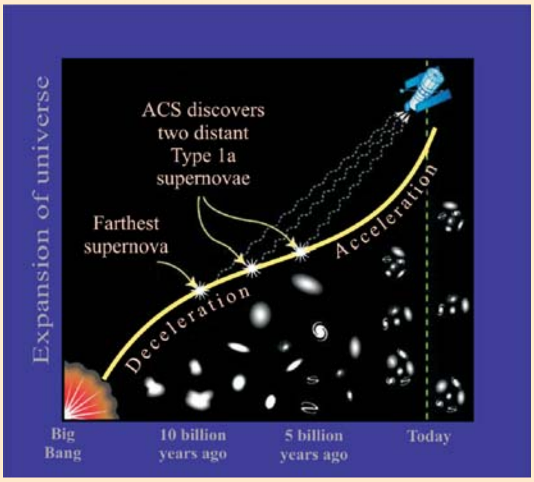
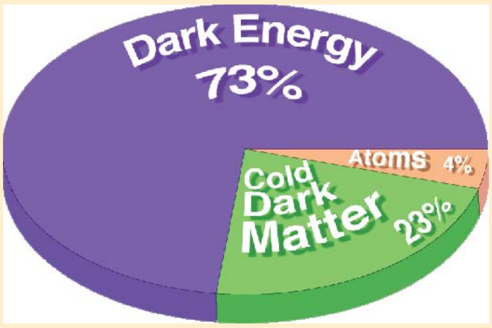


Image credit: NASA/ESA and A. Field

Cosmic acceleration came as a real surprise to the astronomers. Almost 75 years ago the American astronomer Edwin Hubble had discovered the uniform expansion of space; and now the scenario stands much more complicated. Cosmologists and particle physicists have seldom felt so confused. Although, our standard model of cosmology has been confirmed by recent observations, it still has a gaping hole: nobody knows why the expansion of universe is accelerating. Researchers commonly attribute the acceleration to some mysterious entity called dark energy, but there is little physics to back up these fine words. The only thing that is becoming clear is that at the largest observable distances, gravity behaves in a rather strange way, turning into a repulsive force.

Cosmologists can use the cosmic microwave background radiation to measure the proportions of ordinary matter, dark matter and dark energy. They have discovered that an outrageous 70% of the universe is made of dark energy; sounds quit improbable isn't it? The rest 30% is matter. 26% of the universe is made of



dark matter and remaining just 4% is ordinary matter. Whether or not the expansion is slowing down or speeding up depends upon a battle between two titans – the attractive gravitational pull of matter and the repulsive gravitational push of dark energy.

What is dark energy?

Dark energy is truly a bizarre form of matter, or perhaps, a property of vacuum itself, that is characterized by a large negative pressure. While the attractive gravity of mostly dark matter slows down the expansion of the universe, a mysterious repulsive pressure or negative pressure of dark energy tends to speed it up. The Hubble Space Telescope is continuing to gather supernova data that could help determine more precisely the transition point between the slow down and the speed up. This will perhaps, in return, help astrophysicists to find out how the energy density of dark energy has evolved over time and perhaps discover its true nature.

Possible future scenario of the Universe

So what is the ultimate fate of the universe? Will a flat universe with a positive vacuum energy expand forever with ever increasing rate? There are three distinct theoretical possibilities provided we accept that dark energy rises and falls over time. This is a direct consequence of the fact that in the distant past the density of matter – dark and ordinary, should have been greater, so the expansion should have been slowing down. The density of matter decreases as the universe expands because, the volume of space increases. This leads to the increase in density of dark energy with its repulsive force resulting into accelerated expansion. If the dark energy is constant or is increasing with time, in 100 billion years or so all but a few hundred galaxies will be far too red shifted to be seen. The Virgo Cluster will no more remain within our visible horizon. But, if the dark energy density decreases and matter becomes dominant again, our cosmic horizon will grow, revealing more of the universe and more distant galaxy clusters. Even more lethal futures are possible. If dark energy density rises rather than falls, the universe will undergo a run away expansion – a hyper speed-up – that would eventually tear apart galaxies, solar systems, planets and even atomic nuclei in that order. Or the universe might even re-collapse if dark energy density falls to a negative value.

The cosmic conundrum

Solving the mystery of cosmic acceleration will reveal the destiny of our universe. But what is dark energy? No existing theory has a definitive answer to this. Albert Einstein introduced the concept of dark energy in 1917, when he included the cosmological constant in his equation to counteract the influence of gravity. In absence of much observational data then, Einstein had a belief that the universe was static – neither expanding, nor contracting; the cosmological constant countered the influence of gravity to stop the universe from collapsing on to itself. But, within little more than a decade's time Edwin Hubble's observational evidence of expanding universe was a terrible blow to that concept of dark energy.

Einstein famously retracted his term for cosmological constant from his equation declaring that was the biggest blunder of his life. On the eve of the new millennium however Einstein's dark energy has got a resurrection, albeit in a little modified form. Few theorists explain that dark energy is actually a property of pure vacuum. But, no theorist, not even quantum physicists, can explain why this energy is much smaller than any predicted value.

Is Einstein's theory incomplete as it is incompatible with even less fundamentally strong but quite successful theories of quantum physics? Is string theory the answer – with its six or seven additional but invisible dimensions over and above the usual three dimensions of space? Does gravity has a Houdini-like ability to escape or leak into the higher dimensions? Or, do we need to change the existing laws of physics? Perhaps, the more radical idea is that there is no dark energy at all; rather Einstein's theory of gravity must be modified.

Epilogue

Physics of vacuum or nothingness will determine the fate of our universe. To reveal the physics of dark energy more than half a dozen ground based telescopes are also gearing up for detailed observations. The most ambitious space based project is the 'Joint Dark Energy Mission' proposed by the US Department of Energy and NASA. It is a two-meter, wide-field space telescope dedicated for this purpose and is to be launched at the start of the next decade. The European Space Agency also plans to launch the *Planck* spacecraft in 2007. The spacecraft is designed to observe the earliest cosmic background radiation with even greater sensitivity and resolution. We hope to probe out the true nature of the universe pretty soon. The future remains anything but bleak and boring! Do stay tuned.

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How many planets in the sky?

Part I – Planets in the solar system

❑ Prof. K.D. Abhyankar

Introduction

"How many planets are there in the sky?" If we had asked this question in ancient times in India the answer would have been: There are seven planets (*grahas*) or luminous moving bodies in the sky. And they would have been immediately counted as *Ravi*, *Soma*, *Mangala*, *Budha*, *Guru*, *Shukra*, and *Shani*. The last five were called *taragrahas* as they had no disks like the Sun and the Moon. All the seven planets were supposed to go round the Earth at different distances proportional to their periods. Based on this concept the ancients conceived of seven *lokas* or regions of the universe, viz., *Bhuloka* – the earth, *Bhuvarloka* or *Antariksha* – the region of the Moon, *Swarloka* – the region of the Sun including Mercury and Venus, which never moved far away from the Sun, *Maharloka* – the region of Mars, *Janaloka* – the region of Jupiter, *Tapaloka* – the region of Saturn and *Satyaloka* – the region of the stars.

At a later time two more shadowy grahas – *Rahu* and *Ketu* – were added for explaining the occurrence of solar and lunar eclipses, thus increasing the number of planets to nine. However, it was soon realized that *Rahu* and *Ketu* are nothing but the intersections of the paths of the Sun and the Moon in the sky. So the number of planets came back to seven.

Study of the solar system

The movements of the seven planets around the Earth were explained by the Alexandrian astronomer and mathematician Plotemy and the Indian astronomer Aryabhata through the device of 'deferents' (*Kakshãvrittas*) and 'epicycles' (*Neechoccchavrittas*). This geocentric picture was changed by the revolutionary hypothesis of the Polish astronomer Nicolas Copernicus in 1543 according to which the five *taragrahas* and the Earth moves round the Sun, and only the Moon moves round the Earth. It was then realized that the Sun and the moon were different from the other luminaries. So there three kinds of objects viz. the Sun, six planets going round the Sun, and Moon which was called the satellite of Earth.

The Danish astronomer Tycho Brahe did not like the idea of Copernicus that the Earth moved round the Sun, because he did not find any proof of Earth's motion (which came much later). So he suggested in 1786 that the five *taragrahas* did move round the Sun, but the Sun moved round the Earth. It may be noted that this so called 'Tychonic system' was postulated by Indian astronomer Neelakantha Somayaji of Kerala much earlier, in 1500, and it was independently arrived at by another Indian astronomer Sãmanta Chandrasekhara of Orissa in 1899.

However, the importance of the Sun as the central body was firmly established by the German astronomer Johannes Kepler during 1602 – 1619 through his three laws of motion of planets in elliptical orbits around the Sun, and by the English physicist, mathematician Isaac Newton in 1687 through his universal law of gravitation. It was confirmed by the English astronomer Edmond Halley who showed in 1705 that comets also moved round the Sun in highly elliptical orbits. Further support came with the discovery of four satellites of Jupiter by the Italian astronomer Galileo Galilei in 1610 and one satellite of Saturn by the Dutch mathematician, physicist Christian Huygens in 1705. In this way the solar system was found to contain three distinct kind of objects, viz., six planets moving round the Sun in nearly circular orbits, half a dozen satellites moving round the planets, and about a dozen comets moving in highly elliptical orbits around the Sun. This required the development of the new discipline of celestial mechanics for studying the motions of all these bodies on the basis of Newton's theory of gravitation.

Kepler's and Newton's theories gave accurate relative distances of planets from the Sun in terms of the Earth's distance, known as Astronomical Unit (AU), because according to Kepler's law the cube of the distance of planet from the Sun 'a' is proportional to the square of its orbital period 'P'; i.e., a^3 is proportional to P^2. In 1766 the German astronomer Johann Bode discovered an empirical law for planetary distances, which is known as Titius-Bode's Law, which gave an empirical relationship between the mean distances of the planets from the Sun. If each number in the series 0, 3, 6, 12, 24,...(where a new number is twice the previous number) is increased by 4 and divided by 10 to form the series 0.4, 0.7, 1.0, 1.6, 2.8, 5.2, 10.0, 19.6, 38.8, 77.2,..., Bode's law holds that this series gives the mean distances of the planets from the Sun, expressed in astronomical units (AU). This law was confirmed by the discovery of Uranus by the German-born British astronomer William Herschell in 1781 at a distance of about 19.6 AU, and of the asteroids Ceres, Palas, Juno and Vesta at a distance of 2.8 AU. However, the asteroids were not recognized as planets as they are too small in size. In fact, now several thousand of asteroids are known to exist between the orbits of Mars and Jupiter and are also known as 'minor planets'. So the number of planets became seven again.

Use of celestial mechanics for discovering planets

After the discovery of Uranus it was found that the earlier computations and later observations of Uranus gave different value for it orbit. So it was thought that Uranus was being disturbed by the gravitational attraction of another planet farther out from the Sun. Bode's law gave for it a distance of 38.8 AU. Taking this as a guide the English astronomer John Couch Adams in 1846 and the French astronomer mathematician Urbain Leverrier in 1848 made calculations and predicted the existence of a planet at 37 AU with a mass of 35 to 50 times the mass of the Earth. The predicted planet was discovered by the German astronomer Johann Gottfried Galle in 1847, but its distance came out to be 30 AU, thus disproving the validity of Bode's law. Also the mass of the planet was proportionally reduced to 17 times the mass of Earth. The new 8th planet was named Neptune.

Later during 1866-1877 Leverrier worked on a complete gravitational theory of all planets and found that there were discrepancies between the observed and calculated positions of both Uranus and Neptune. So astronomers began to think of a planet beyond Neptune. Using the methods of celestial mechanics the American astronomer Percival Lowell predicted a Planet 'X' at 43 AU with a mass of 6.5 times the mass of Earth, while another American astronomer William Pickering predicted a planet 'O' at 55 AU with a mass twice the mass of Earth. The Indian astronomer V.B. Ketkar also predicted two planets at 40 and 60 AU based on the resonances between planetary periods.

Lowell founded an observatory at Flagstaff, USA, specifically for discovering the predicted planet. The young American astronomer Clyde Tombaugh worked on this project for 25 years examining several thousands of plates taken during 1905 and 1930. He was finally successful in discovering Pluto in January 1930, at 39.4 AU. Pluto became the 9th Planet. On the basis of its brightness it was estimated to have a mass of 0.4 times the mass of Earth. Later the American-born Dutch astronomer Gerard Kuiper measured Pluto's diameter to be 3,600 km and estimated its mass as one-tenth that of Earth. However, the discovery of Pluto's satellite Charon by the American astronomer James Christy in 1978 showed that Pluto's mass is only one-fifth that of our Moon; that is, it is 1/400th the mass of Earth. Its diameter was also more accurately measured as 2,280 km. So small a planet cannot be responsible for disturbing Uranus and Neptune. So astronomers began to think of a 10th planet beyond Pluto.

Search for the tenth planet

The problem of the tenth planet was tackled with several different approaches. The earlier path of celestial mechanics was followed by Powell who predicted a planet at a distance of 34.6 AU with a period of 204 years and mass of 0.35 times the mass of Earth. Based on these predictions 70 per cent of the whole sky was scanned by Tombaugh for 14 years in the hope of discovering the planet. He found 4,000 asteroids, but no planet. Another American astronomer Charles T. Kowal also failed in a similar search in the region spread over 15^{o} on either side of the ecliptic.

The American astronomer J.L. Brady attacked the problem from a different angle. It is found that Halley's comet is delayed by a few days during each of its close approach to the Sun. Brady alluded this to the effect of the tenth planet for which he obtained a distance of 60 AU with a period of 464 years and a mass of 200 times that of Earth. A search for Brady's planet by several astronomers proved fruitless. It was later found that ejected material form Halley's comet produced a jet action which disturbed its motion and a tenth planet was not necessary for that purpose.

The American astronomer Thomas Harrison had a different idea. Pluto has a highly eccentric orbit, which brings it closer to the Sun than Neptune at perihelion. So it was argued that it might have been a satellite of Neptune, which escaped from it due to the influence of an outer planet. Harrison computed for it an orbit with a radius of 101 AU, an orbital period 1,092 years, and a mass of 4 times that of Earth.

In spite of the failure of Bode's law the Indian astronomer J.J. Rawal tried in 1978 to fit a different law for planets starting from Saturn, according to which there should be no planet at Pluto's distance, but there could be two planets at distances of 52 and 99 AU from Sun. In the mean time space probes improved the accuracy of the orbit and masses of Uranus and Neptune and there was no further discrepancy in their observed and calculated positions.

The Kuiper Belt

In 1992 the English astronomer David Hughes argued that there is no possibility of having a large planet beyond Neptune, as there would be very little material in that region left of the solar nebula. So attention was drawn to an earlier suggestion of Kuiper that Pluto and Charon may be the members of a group of small bodies moving in asteroid-like orbits beyond Neptune, which is known as Kuiper Belt. Hubble Space Telescope indeed found 235 Kuiper Belt Objects (KBO's). It is estimated that there may be 200 million of them larger than 1 km in diameter. But it was expected that some objects of Pluto's size might be present. In the last few years half a dozen KBO's of that type have been discovered and one of them (named Xena) is considered to be the tenth planet. Let us examine this claim.

Table 1 lists the large KBO's and Table 2 compares the orbital elements of Xena and Pluto.

Table 1: Large Kuiper Belt Objects

Description	Name	Diameter (km)	Surface
2003 UB313	Xena	2,900	CH_4
	Pluto	2,280	CH_4
2005 FY9	Easter Bunny	1,800	
	Sedna	1,600	ice
2003 EL61	Santa	1,500	ice
	Charon	1,250	ice
	Quoaar	1,250	

Table 2: Orbital elements of Xena and Pluto

Parameter	Xena	Pluto
Major axis (AU)	67.5	39.4
Eccentricity (e)	0.43	0.25
Distance from Sun (AU)	38 to 99	29.6 to 49.3
Inclination (i)	44°	17°
Diameter (km)	2900	2280
Orbital period (yrs)	557	247

It may be noted that the distance of Xena does not agree with any of the predicted values. But if Pluto is considered a planet, then Xena is also a planet. Then what about the other large KBO's? They are all similar to large and medium satellites listed in Table 3.

Table 3: Large and medium satellites

Name (Planet)	Diameter (km)	Mass in terms of mass of Moon	Surface
Ganymede (Jupiter)	5,278	2.02	Ice
Titan (Saturn)	5,174	1.83	Ice
Callisto (Jupiter)	4,820	1.47	Ice
Europa (Jupiter)	4,705	1.22	Dry
Moon (Earth)	3,476	1.00	Dry
Io (Jupiter)	3,146	0.65	Ice

At the other end we have asteroids: Ceres with a diameter of 940 km, Pallas with a diameter 540 km, and Vesta with a diameter 510 km. Of these, satellites are not considered planets as they do not revolve round the Sun, and asteroids that do revolve round the Sun are not considered planets because they are too small. It is therefore logical to call the KBO's, which move round the Sun but are small, by some other name like planetoids rather planets. In that case there are only eight planets in the solar system.

We shall consider extrasolar planets in Part II of this article.

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(Contd. from page 39)

Evolution – Can It Run Backwards?

to the fact that people are providing bird feeders filled with rice and hence it is no longer a disadvantage to have an intermediate beak! Apparently everybody can eat this rice! Is the impact of human beings on environment forcing evolution into reverse?

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

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

❒ V. B. Kamble

Osteoporosis

Lock the Bone Thief Out

❑ Dr. Yatish Agarwal
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As you go past the age of forty, your bones need extra care. If you are careless, they tend to become abnormally porous and thin. A silent thief – osteoporosis – quietly robs them of their banked resources. Slowly and surely the bones lose their reserves of calcium and phosphorous, and become so weak that they cannot bear the normal rigours of life. They can give in anytime and bring life to a grinding halt.

A common bone disorder, osteoporosis, moves in tandem with age. People in middle and old age are often affected by it, but women, who have stopped menstruating, are particularly vulnerable. Age-related bone loss begins at the age of forty, but speeds up in women after menopause. By the age of seventy-five, skeletal mass may be reduced to half of what it was at the age of thirty.

Somewhere along the line, the loss becomes critical and gets evident when a weakened bone suffers a fracture. Commonly, it is one of the bones of the vertebral column, wrists, or the neck of the thigh-bone which breaks to cause pain, restriction of movement and, on many occasions, loss of independence. This can be acutely depressing at this age, particularly in the present era.

There are times, however, when the quiet misdemeanour of osteoporosis sets in at a younger age. This happens when some partners-in-crime get the opportunity to join hands with it. Lack of weight-bearing exercises; smoking; heavy alcohol intake; long-term dependence on corticosteroids, anti-epileptics, heavy metals and hormones; repeated pregnancies without adequate gap, and insufficient nutritional adjustment; a chronic illness; myeloma and deficiencies of specific minerals (calcium) and vitamins (vitamin D and C) due to an inadequate intake or a faulty metabolism, can lead to premature osteoporosis.

But the good news is you can police the loss and stop further damage, if you try sufficiently. All it needs is some changes in lifestyle, which will help build and maintain bone mass and keep the bone thieves at bay. Read on.

GET ENOUGH CALCIUM : A well-balanced diet, containing sufficient amount of calcium-rich foods is absolutely essential for building up and the maintenance of strong and healthy bones. This rule applies to all, but particularly to adolescent girls, who eat poorly and consume little amounts of calcium; also pregnant and post-menopausal women, who need extra amount of calcium in their diet.

Many studies have highlighted the positive role of dietary calcium: women taking a good amount of calcium enjoy a greater bone mass and suffer much fewer fractures in their old age than women who live on low-calcium diets.

The recommended daily allowance of calcium for adults is five hundred-six hundred milligrams. It increases to thousand milligrams in pregnant women and nursing mothers. Post-menopausal women and people over sixty-five need five hundred milligrams extra. Milk is the best source. Half a litre of standard cow's milk contains about six hundred milligrams of calcium. Many other foods are also rich in calcium. Here's a list:

- All dairy products (e.g. cheese, yoghurt, skimmed milk and butter milk)
- Fruits like custard apple, dried raisins, apricots and dates
- Fish, in particular, saltwater fish like salmon
- Cereals, particularly *ragi* (a millet popular in South India)
- Green leafy vegetables such as turnip and mustard greens
- Drinking water

TAKE CALCIUM SUPPLEMENTS : If you can't get enough calcium in the diet, you might consider taking calcium tablets regularly with your doctor's advice. They are available in many interesting shapes and sizes, and wonderfully attractive packs.

REMEMBER VITAMIN D : Vitamin D is crucial for calcium absorption. You can get sufficient amounts of it from sunlight if you spend enough time in the Sun. But it works to your advantage if you take an additional hundred IU (international units) in the diet. In women who have attained menopause and people over the age of sixty-five, the daily requirement increases to four hundred IU.

Vitamin D is present in good amount in many of the foods that give you calcium. Milk, salmon, sardines and tuna are its best natural sources. But bread and vegetable oils are also artificially fortified to meet the human body's requirement.

EXERCISE REGULARLY : The bones respond to forces put through them by an increase in strength and mass. You should begin early in life and continue throughout life. Weight-bearing activities such as walking, dancing, low-impact aerobics (water or dry land) and stationary cycling are all excellent forms of exercise.

In case you already have osteoporosis, and suffer from pain, the choice of exercise will obviously be more limited. Swimming may be a form of exercise that is tolerable and beneficial. Consult your physician or physiotherapist to discuss methods of exercise. In addition to preventing bone loss or rebuilding bone, exercise can also strengthen muscles, thus facilitating better balance, support and flexibility. This can help in preventing falls, a prevalent cause of injury in older individuals.

Individuals who have suffered fractures of the spine or hip, or who have postural abnormalities secondary to osteoporosis, may be given a specific exercise programme designed to improve mobility of joints, particular muscle strength and posture.

Your physician is the best informed person to advise you on the forms of exercise that are likely to be helpful. Walking, in any case, is the best bet. Walk thirty to forty minutes a day, four to five days a week, and chances are that you will never have osteoporosis.

On the other hand, if you do not exercise, and remain absolutely sedentary, your bones will gradually lose their strength.

DO NOT SMOKE : Cigarette smoking also weakens the bones. So here is another firm reason to call it quits.

PUT A LIMIT ON CAFFEINE : Coffee, tea and colas are no friends of our bones. Caffeine aggravates osteoporosis. Limit yourself to no more than three cups of coffee or tea a day. Colas are best avoided altogether.

CUT DOWN ON ALCOHOL : Alcohol impairs bone formation. So drink in moderation and fix your limits at a maximum of one to two drinks a day.

NEVER TOY WITH STEROIDS : They may be taken only under the strict supervision of your doctor. A prolonged intake of steroids can most certainly lead to osteoporosis.

CONSIDER NOVEL TREATMENTS : You could take biphosphonates like sodium alendronate (Osteofos) and pamidronate, etidronate or calcitonin (Calsynar) to check osteoporosis. You can talk to your doctor about their merits and drawbacks before you try them.

In post-menopausal women, hormone replacement therapy (HRT) is also recommended since the dip in oestrogen hormone plays a major hand in causation of osteoporosis. However, HRT is not without its risks, and you must be careful about its use. Talk to your doctor, understand the advantages and risks, and only then decide.

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Earthquake Tip 1 – What Causes Earthquakes?

Indian Institute of Technology, Kanpur, and the Building Materials and Technology Promotion Council, New Delhi, have developed the "IITK-BMTPC series on Earthquake Tips". The series consisting of 24 "tips" is being serialized in DREAM 2047 through a special arrangement for which we are grateful to Professor Sudhir K. Jain, Department of Civil Engineering, IIT, Kanpur.

The Earth and its Interior

Long time ago, a large collection of material masses coalesced to form the Earth. Large amount of heat was generated by this fusion, and slowly as the Earth cooled down, the heavier and denser materials sank to the center and the lighter ones rose to the top. The differentiated Earth consists of the *Inner Core* (radius about 1,290*km*), the *Outer Core* (thickness about 2,200km), the *Mantle* (thickness about 2,900km) and the *Crust* (thickness about 5 to 40km). The Inner Core is solid and consists of heavy metals (*e.g.,* nickel and iron), while the crust consists of light materials (*e.g.,* basalts and granites). The outer core is liquid in form and the mantle has the ability to flow. At the core, the temperature is estimated to be around 2,500°*C*, the pressure about 4 million atmospheres and density about 13.5 g/cm^3; this is in contrast to a temperature of around 25°*C*, a pressure of 1 atmosphere and a density of 1.5 g/cm^3 on the surface of the Earth.

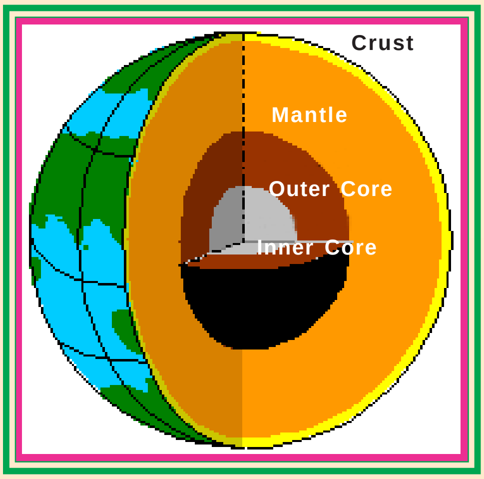

Figure 1: Inside the Earth

The Circulations

Convection currents develop in the viscous mantle, because of prevailing high temperature and pressure gradients between the crust and the core, like the convective flow of water when heated in a beaker. The energy for the above circulations is derived from the heat produced from the incessant decay of radioactive elements in the rocks throughout the Earth's interior. These convection currents result in a circulation of the Earth's mass; hot molten lava comes out and the cold rock mass goes into the Earth. The mass absorbed eventually melts under high temperature and pressure and becomes a part of the mantle, only to come out again from another location, someday. Many such local circulations are taking place at different regions underneath the Earth's surface, leading to different portions of the Earth moving in different directions along the surface.

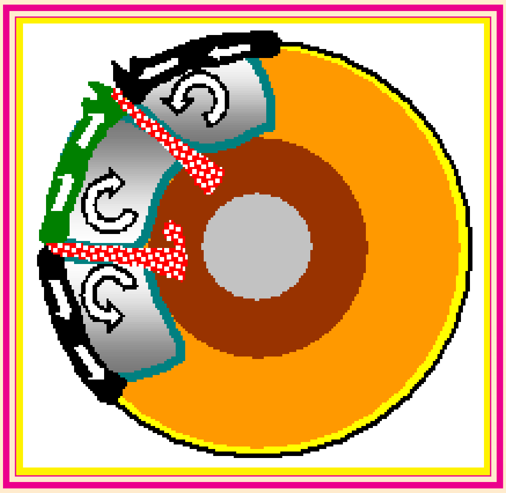

Figure 2: Local Convective Currents in the Mantle

Plate Tectonics

The convective flows of mantle material cause the crust and some portion of the mantle, to slide on the hot molten outer core. This sliding of Earth's mass takes place in pieces called 'Tectonic Plates'. The surface of the Earth consists of seven major tectonic plates and many smaller ones. These plates move in different directions and at different speeds from those of the neighbouring ones. Sometimes, the plate in the front is slower; then, the plate behind it comes and collides (and mountains are formed). On the other hand, sometimes two plates move away from one another (and 'rifts' are created). In another case, two plates move side-by-side, along the same direction or in opposite directions. These three types of inter-plate boundaries are known as the convergent, divergent, and transform boundaries, respectively. The convergent boundary has a peculiarity (like at the boundary of the Himalayas) that sometimes neither of the colliding plates wants to sink and both rise up. The relative movement of these plate boundaries varies across the Earth; on an average, it is of the order of a couple to tens of centimetres per year.

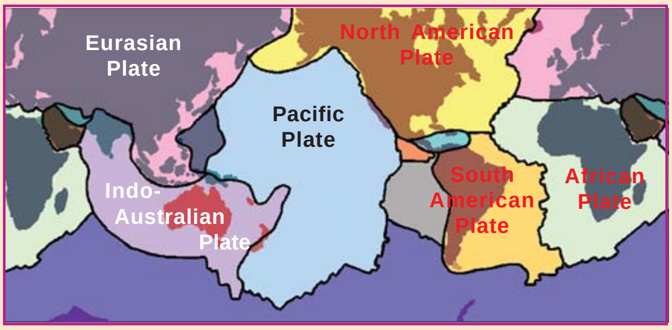

Figure 3: Major Tectonic Plates on the Earth's surface

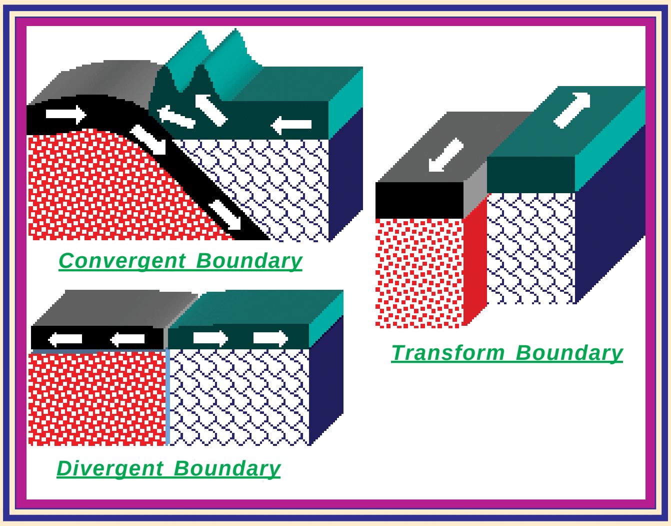

Figure 4: Types of Inter-Plate Boundaries

The Earthquake

Rocks are made of elastic material, and so elastic strain energy is stored in them during the deformations that occur due to the gigantic tectonic plate movements at the plate boundaries. But, the material contained in the rocks is also very brittle. Thus, when the rocks along a weak region in the Earth's crust are stressed beyond limit, a sudden movement takes place there; opposite sides of the 'fault' (a crack in the rocks where movement has taken place) suddenly slip and release the large elastic strain energy stored in the interface rocks. For example, the energy released during the 2001 Bhuj (India) earthquake was about 400 times or more than that released by the 1945 atom bomb dropped on the Japanese city of Hiroshima!

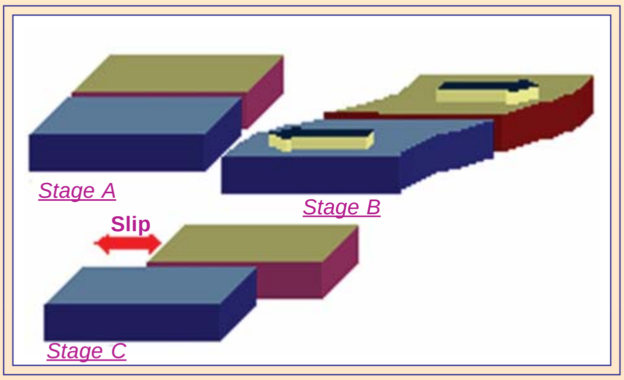

Figure 5: Elastic Strain Build-Up and Brittle Rupture

The sudden slip at the fault causes an earthquake – a violent shaking of the Earth when large elastic strain energy released spreads out as seismic waves that travel through the body and along the surface of the Earth. After the earthquake is over, the process of strain build-up at the modified interface between the rocks starts all over again. Earth scientists know this as the 'Elastic Rebound Theory'.

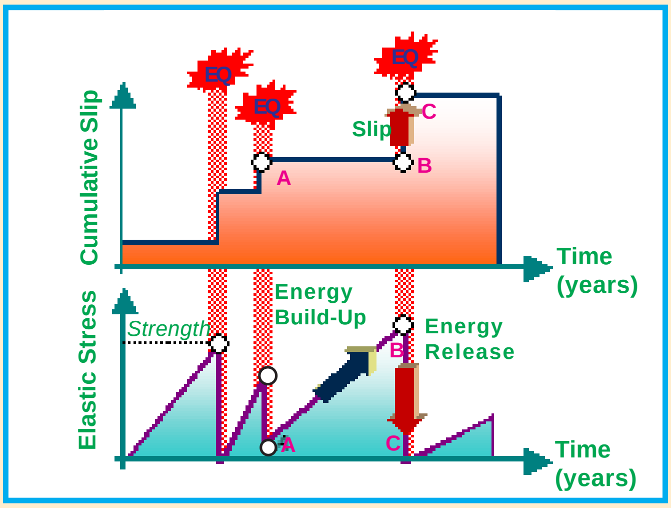

Figure 6: Elastic Rebound Theory

Types of Earthquakes and Faults

Most earthquakes in the world occur along the boundaries of the tectonic plates and are called 'Inter-plate earthquakes' (*e.g.,* 1897 Assam earthquake). A number of earthquakes also occur within the plate itself, away from the plate boundaries (*e.g.,* 1993 Latur earthquake); these are called 'Intra-plate earthquakes'. In both types of earthquakes, the slip generated at the fault during earthquakes is along both vertical and horizontal directions, called 'Dip slip', and lateral directions, called 'Strike slip', with one of them dominating sometimes.

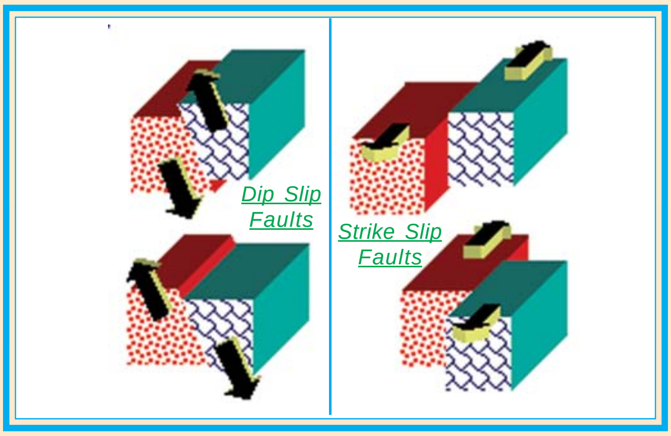

Figure 7: Type of Faults

Reading Material

1. Bolt, B.A., (1999), *Earthquakes*, Fourth Edition, W. H. Freeman and Company, New York, USA
2. http://earthquake.usgs.gov/faq/
3. http://neic.usgs.gov/neis/general/handouts/general_seismicity.html
4. http://www.fema.gov/kids/quake.htm

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Recent Developments in Science and Technology

Vaccine against cervical cancer

A Swiss team of researchers has developed a vaccine against cervical cancer that does not need to be injected. Simply inhaling the vaccine could protect women against the disease. Preliminary tests have shown the vaccine can trigger an immune response similar to that seen with the injectable vaccine. Denise Nardelli-Haefliger of the University of Lausanne in Switzerland, who leads the team developing the vaccine, presented the results at the conference of the European Research Organization on Genital Infection and Neoplasia in Paris.

The aerosol spray vaccine consists of particles derived from the outside of 'human papilloma virus 16', one of four strains of the virus that cause majority of cervical cancer cases. When inhaled, it stimulates production of antibodies against the virus. The spray needs two doses, spaced two weeks apart, compared to the injectable vaccine, which requires three doses over six months.

Source: www.newscientist.com

Chocolate generates electrical power

Microbiologist Lynne Mackaskie and her colleagues at the University of Birmingham in the UK have devised a fuel cell that is powered by feeding chocolate-factory waste to sugar-loving bacteria. The team fed *Escherichia coli* bacteria diluted caramel and candy waste. The bacteria consumed the sugar and produced hydrogen, which they make with the enzyme hydrogenase, and organic acids. The researchers then used this hydrogen to power a fuel cell, which generated enough electricity to drive a small fan, as reported in *Biochemical Society Transactions* (Vol 33, p 76).

The process could provide a use for chocolate waste that would otherwise end up in a landfill. What's more, the bacteria can also be used to recover precious metal from the catalytic converters of old cars. When placed in a vat with hydrogen and liquid waste from spent converters, the bacteria helps enzymes split the gas into its constituents, generating electrons that react with palladium ions in the solution. This forces the palladium out of the solution, and it sticks to the bacteria. The palladium-coated bacteria can then be recycled as catalysts for other projects, Mackaskie says.

Source: www.newscientist.com

Ozone and Cholesterol Combine to cause Heart Disease

Numerous studies have linked heart disease and air pollution, particularly smog. Smog – a toxic brew of chemicals and molecules such as ozone – seems to exacerbate heart disease, leading to an increase in heart attacks and fatalities. But researchers have yet to discover the pathway by which smog impacts the cardiovascular system. Now a new study shows how ozone's byproducts in the body can harden arteries and cause heart disease.

Chemist Paul Wentworth, Jr., of the Scripps Research Institute and his colleagues tested such byproducts – known as atheronals – *in vitro.* These molecules form when ozone and cholesterol interact. "Cholesterol makes up 40 percent of most of your membranes, including those in your lungs," Wentworth explains. "If you inspire smog, there directly is the interaction."

The team's previous research had shown that the white blood cells responsible for inflamming arterial walls also produce ozone and, ultimately, the atheronals. These compounds are present in the plaque removed from clogged arteries. The new research shows that when the atheronals interact with various blood cells, they produce some of the effects known to lead to heart disease, such as causing a malfunction in the cells that line arterial walls.

Source : *www.sciam.com*

Ultra-efficient Organic LED Outshines Lightbulb

The incandescent light bulb is a miracle of modern engineering. It requires a vacuum inside, blown glass and special filaments to work. Yet despite more than a century of refinements, an average bulb emits just 15 lumens of light for every watt of electricity it consumes. As a result, simple lighting accounts for 22 percent of the electricity used by buildings in the U.S. Now a team of engineers and chemists has created a carbon-based series of light-emitting diodes (LEDs) that operate at the pinnacle of efficiency while emitting a strong white light

Electrical engineer Stephen Forrest of the University of Michigan, chemist Mark Thompson of the University of Southern California, USA and their colleagues created the so-called organic LED by combining two layers of phosphorescent diodes – to release green and red wavelength light – and one layer of a fluorescent diode to supply blue wavelength light. Together, they produce white light much more efficiently than current incandescent or fluorescent bulbs.

The diode also requires a lower voltage than purely phosphorescent devices do thanks to its fluorescent component, the researchers note in the paper presenting the finding in journal, *Nature* (Vol. 440, p.908). Furthermore, because the organic layers are only 10 nanometers thick, and transparent when turned off, they can be built into walls, furniture or even windows.

Source: www.sciam.com

Complied by : Kapil Tripathi

Arvind Bhatnagar (1936-2006)

Prof. Arvind Bhatnagar passed away on the evening of 18 May 2006 at Udaipur following severe cardiac and respiratory complications. He had returned to his city, Udaipur, just one day before, on 17 May 2006, after spending two months in Delhi where he was recuperating from cardiac problems. Although he was not keeping good health over the last few years, he had retained his enthusiasm and dynamism as ever to be actively engaged in both research and social activities. As the Arvind we all knew, he had pushed behind his urgent personal commitments and rather chose to avail an opportunity to observe the total solar eclipse of 29 March 2006 from Turkey. While making the arrangements for his trip, he stretched beyond what his body could take and the cardiac problems decimated his plans.

Arvind Bhatnagar

Prof. Bhatnagar was known internationally for his significant contributions to Solar Astronomy. He was the founder-director of the Udaipur Solar Observatory. He also took immense interest in popularization of astronomy and helped establish several planetaria across India.

Arvind Bhatnagar was born in Beawar, Rajasthan on 19 November 1936. He had his early education in Agra, Almora, and Nainital. After completing his M.Sc. in Physics, he joined the UP State Observatory, Nainital, in 1958 and worked there until 1961. He obtained his Ph.D. degree in Solar Physics in 1964 from Agra University while working at the Kodaikanal Observatory under the guidance of Prof. M. K. Vainu Bappu. He worked as a meteorologist with the India Meteorological Department during 1965-67. He was awarded the Carnegie Fellowship to work at Mount Wilson and Palomar Observatories, USA, during 1968-70. Afterwards he worked as a Resident Astronomer at the Big Bear Solar Observatory of the California Institute of Technology, Pasadena, California, USA till 1972.

In 1972, Prof. Bhatnagar returned to India to establish a unique island solar observatory in the middle of Lake Fatehsagar in Udaipur under the aegis of the Vedhshala, Ahmedabad. He had carefully selected this lake site after taking into consideration the facts that Rajasthan received the maximum sunshine and the large body of lake water helps to stabilize the air turbulence arising due to heating of ground by the solar radiation. The Udaipur Solar Observatory has become internationally renowned as one of the major centres for high-resolution solar observations. It is also one of the six observatories located around the world participating in the Global Oscillations Network Group (GONG) for the study of solar interior.

In December 1996, Prof. Bhatnagar retired as the director of the Udaipur Solar Observatory, and continued to work on topics related to the solar interior as an Emeritus Scientist. He worked on helioseismology using the GONG data and studied the p-mode frequency shift with the phase of solar cycle. He co-authored with Bill Livingston a fascinating book on solar physics entitled “Fundamentals of Solar Astronomy”, and had recently embarked on another book entitled “Manual for Solar Astronomy – for beginners” funded by DST. He wrote more than 80 papers on a wide variety of problems and edited two books.

Prof. Bhatnagar was elected a Fellow of the prestigious National Academy of Sciences, India (Allahabad). He was a founder member of the Astronomical Society of India and a member of the International Astronomical Union. Dr. Bhatnagar was the founder Director of the Nehru Planetarium, Mumbai and was its Director from 1976 to 1978. He was advisor to many planetaria in the country, namely Jawahar Planetarium, Allahabad, Nehru Planetarium, Delhi, and Sardar Patel Planetarium, Baroda. He encouraged a number of young students to take up active interest in pursuing scientific activities and also guided several students during their research career.

In 1996, Prof. Bhatnagar started a novel project called SUCHE (Swatch, Healthy, Urban, Clean and Hygienic Environment) Abhiyan in several localities of Udaipur under ASTHA Sansthan for solid waste management through public participation. He was also appointed as one of the High Court Commissioners to monitor the directives of the High Court in connection with protection of the lake system of Udaipur. In his passing away we have lost a person with unique characteristics and capabilities and it will be difficult to fill up this void.

Dr. Bhatnagar had a long association with Vigyan Prasar, and was an integral part of the Total Solar Eclipse Expeditions undertaken by Vigyan Prasar in 1995 and 1999, which were visible from India. He was instrumental in conducting experiments on board the aircraft MiG 21 in association with Indian Air Force. The MiG 21 aircraft flew under the umbral shadow of the Moon at a height of 24,400 metres and photographed the solar corona. On the rare occasion of the Venus Transit on 8 June 2004, Vigyan Prasar in association with Doordarshan organised a two-hour live programme on the DD National channel. Dr. Bhatnagar was one of the experts, along with Professor Yash Pal and Dr. V. B. Kamble, who gave interesting information about this rare phenomenon and answered viewers’ questions.

Dr. Ashok Ambastha, Udaipur Solar Observatory

Sky Map for July 2006

Moon - First Quarter

2 July

Full Moon

10 July

North

East

West

South

Moon - Last Quarter

18 July

New Moon

25 July

The sky map is prepared for viewers in New Delhi. It includes bright constellations and planets. For viewers south of Delhi, constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Rising constellations (in the East) and setting constellations (in the west) are not shown. The map can be used at 10 PM on 1 July, at 9 PM on 15 July and at 8 PM on 30 July.

Tips for watching the night sky:

(1) Choose a place away from city lights/street lights. (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 :

Jupiter: In the constellation *Libra (Tula Rashi)* at zenith.

Neptune and Pluto: Not naked eye objects. Hence not visible.

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

Eastern Sky	:	Aquila (Altair)/*Garuda (Sravan)*, Cygnus (Deneb)/ *Hansa (Hansa),* Capricorns/*Makar Rashi.*
Western Sky	:	Leo (Regulus)/*Simha (Magha)*, Hydra/*Wasuki*, Carvus/*Hasth*, Virgo (Spica)/*Kanya (Chitra).*
Southern Sky	:	Scorpius (Antares)/*Vrischik (Jyeshta)*, Centaurus (Rigel)/*Narturang,* Sagittarius/*Dhanu Rashi.*
Northern Sky	:	Cepheus /*Vrishaparv*, Draco/*Kaleea*, Ursa Major/*Saptarshi*, Ursa Minor (Polaris).
Zenith	:	Lyra (Vega)/*Swaramandal (Abhijeet)*, Bootes (Arcturus)/*Bhutaap (Swati),* Hercules/*Shauri,* Ophiuchus/ *Bhujangdhari,* Corona Borealis/ *Uttar Mukut.*

Arvind C. Ranade