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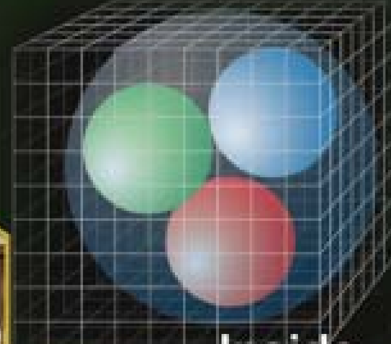
2008 Nobel Prizes in Science



Inside

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

From Spyglasses to Space Telescopes

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

The news of this new invention and the device itself spread quickly throughout Europe. In Italy, Galileo heard about the telescope and decided to build his own. He deduced from the rumours how it must have been designed and constructed one of his own that made the object look three times bigger (that is, a telescope with a magnifying power of 3) in June or July 1609. He presented an 8-power telescope to the Venetian Senate in August. The telescopes he made were of far superior quality than what were available commercially then. In October or November 1609, he turned his telescope with a magnifying power of 20 toward the Moon, the stars, the Milky Way, and the planets. And what he saw stirred great excitement in 17th century Europe.

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

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

The telescopes used by Galileo were made with lenses that typically were only about 2.5 cm (1 inch) in diameter. Over the next 400 years, developments in technology made it possible to build ever larger telescopes with greater light-gathering capacity to detect even very faint objects. Mirrors replaced lenses as the main optical elements in telescopes. Incidentally, the first reflecting telescope was constructed by Isaac Newton in 1668 with an intention to overcome chromatic aberration, or the dispersion of light into different colours as it passed through the lenses in a refracting telescope. William Herschel made a telescope, using one tilted mirror around 1780. He built a number of large telescopes including a 1.2 m (48-

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August Kekulé

Founder of Structural Organic Chemistry

❑ Subodh Mahanti
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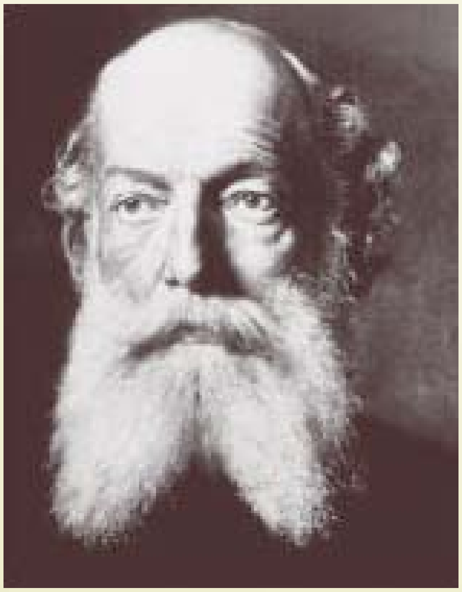
"….Such was the revolution in organic chemistry initiated by Kekulé. Together with new methods introduced by Stanislao Cannizaro at Karlsruhe in 1860 for the determination of atomic weight, a new age of chemistry was about to dawn in which the conflicts and uncertainties of the first half of the 19th century would be replaced by a unified chemical theory, notation, and practice."
A Dictionary of Scientists, Oxford University Press, 1999

"Kekulé's benzene theory was one of the most brilliant ideas of the century. Although it left important problems unresolved, it cast such an unexpectedly clear light on aromatic substances that most practising chemists soon adopted the theory. Most technologically interesting organic compounds (dyes and drugs, for example) were aromatic, and Kekulé's theory became the master key to productive industrial research."
The Oxford Companion to the History of Modern Science, 2003

"Kekulé became a celebrity in his lifetime. To mark the 25 years of the formulation of benzene structure a special international conference was held in 1890. As long as we try to learn about molecules through their structure, Kekulé will be remembered."
Gopalpur Nagendrappa in *Resonance,* May 2001

August Kekulé is regarded as one of the most influential and imaginative chemists of the nineteenth century. It was Kekulé, who first observed that the valency of carbon is always four in organic compounds. He also proposed that unlike most other atoms carbon atom could combine directly with each other to form lengthy and complex chains. Kekulé 's observations started the story of bonding in carbon atoms and chemists' understanding of the structure of organic compounds took a giant leap. Kekulé's most known contribution was his discovery of the structure of benzene. He proposed that benzene was a hexagonal ring of six carbon atoms with alternating single and double bonds in the ring. Each carbon atom in the ring is attached to a hydrogen atom and two other carbon atoms. This discovery not only solved a long standing important problem but it also proved to be a giant leap in the theory of chemical bonding. This discovery made it possible to understand the structure of a class of compounds known as aromatic compounds. Kekulé observed that the study of reaction products can give information about molecular structure.

Archibald Scott Couper (1831-1892) had also proposed the theory of tetravalence of carbon independently of Kekulé and there was a bitter controversy between Kekulé and Couper on the priority of this path-breaking discovery. In his note "Observations on Mr. Couper's New Chemical Theory" published in 1858 Kekulé argued that all the salient features of Couper's paper were first published by himself. Finally Kekulé was given the credit of first proposing the tetravalent nature of carbon atom.


Friedrich August Kekulé

It is generally believed that the impact of Kekulé's contribution to chemistry and the chemical industry is so vast that it may be considered as almost incalculable. According to some people three-fourths of modern organic chemistry is directly or indirectly the result of Kekulé's benzene theory.

Kekule was a great teacher and his contribution to the development of chemistry as a teacher was extremely significant. Students from all over Europe came to him to learn chemistry. Among the first five Nobel Prize winners in chemistry three were Kekulé's students – Jacobus Henricus van't Hoff (1852-1911) in 1901, Hermann Emil Fisher (1852-1919) in 1902 and Adolf von Bayer (1835-1917) in 1905.

Kekulé was a dreamer. He himself admitted that he visualized his major

Stanislao Cannizaro

discoveries in structural organic chemistry in his dreams. He has described his dreams beautifully, as we will see in latter part of this article. Kekulé's dreams have become important lore in the annals of chemistry.

The original name of Kekulé was Friedrich August Kekulé. However, he never used his first name and throughout his life he was known as August Kekulé. After he was ennobled (raised to the rank of a nobleman) by Kaiser Wilhelm II in 1895, Kekulé adopted the name of August Kekule von Stradonitz. The French acute accent over the second 'e' was removed.

Kekulé was born on September 07, 1829 in Darmstadt, Germany. He began his education in the local gymnasium. During his childhood he displayed a great talent for drawing. Young Kekulé enjoyed hiking, studying plants and collecting butterflies. He wanted to be an architect. To realise his goal he joined the school of architecture at the University of Geissen in 1847. He studied architecture for three years and he was determined to pursue a career of architecture. But then a tragic incident brought him in contact Justus von Liebig (1803-1873), which changed the course of Kekulé's life. The body of a lady living next-door to Kekulé was found in charred condition and was beyond recognition. The local police suspected that the servant hired by the lady might be responsible for the incident. They thought so because a ring worn by the lay was missing. During the trial Liebig acted as a forensic expert. Kekulé, was made a witness as he lived next-door to the lady. Kekule was much influenced by the knowledge and skill of Liebig which led to the conviction of the servant. After the trial Kekule visited Liebig's laboratory. He subsequently attended the lectures delivered the great chemist He was so fascinated and inspired by Liebig's lectures that he decided to study chemistry instead of architecture, as he originally intended to do. It may be noted here that Liebig is regarded as the first modern teacher of chemistry. Liebig developed the discipline of chemistry teaching in a large way. He also organized chemical research for the first time.

Initially Kekulé's family was not in favour of his changing to chemistry because they saw no future for him in chemistry. But eventually they had to give their approval seeing Kekulé's persistence. Kekulé's decision immensely benefited chemistry. He ushered in a revolution in organic chemistry and chemical industry.

Archibald Scott Couper

In 1850 he started working in the laboratory of Liebig. Following the advice of Liebig, after graduating in 1851 Kekulé moved to Paris. In Paris he studied chemistry under the guidance of Charles Gerhardt (1816-1856), one of the most distinguished students of Liebig. He returned to his country in June 1852 and soon he was awarded a doctorate degree for his thesis on "The Ester of amyl-sulfuric acid." He stayed in London during the period 1853 to 1855. In London Kekulé worked with Alexander William Williamson (1824-1904), whose work influenced the development of Kekulé's theoretical ideas.

In 1856 he joined the University of Heidelberg as lecturer (Privatdozent). He did not receive any salary for the job. He had to build own laboratory with his own money, which did so by borrowing money from his stepbrother. In 1958 Kekulé went to the University of Ghent in Belgium as Professor of Chemistry. In 1867 he came back to Germany to join as Professor of Chemistry at the University of Bonn, where he worked till his death in 1896.

When Kekulé started doing research in chemistry the two most important questions that concerned chemists were: i) how could one explain the optical isomerism of carbon compounds?; and ii) what was the valency of carbon? Till the mid-19th century there was confusion over the 'combining power' of atoms. Scientists' knew that atoms might combine in more than one proportion as expressed in the 'Law of Multiple Proportions proposed by the Swedish chemist Jöns Jacob Berzelius (1779-1848). In 1834, the French chemist Jean-Baptiste Dumas showed that one atom of chlorine replaced one of hydrogen, one atom of oxygen replaced two atoms of hydrogen. The idea of a 'combining capacity' was first clearly expressed by the English chemist Edward Frankland (1825-1899). Frankland is regarded as the originator of the theory of valence. In 1852 he proposed that each kind of atom could combine with some fixed number of other atoms. For example hydrogen atom can combine with only one other atom at a time, oxygen atom could combine with two, nitrogen atom with three, and carbon atom with four. Such combining power of an atom soon became known as its valence or valency. Kekulé and also Archibald

Adolf von Bayer

Couper realised how to use the insight of Frankland to revolutionise organic chemistry. Both Kekulé and Couper assumed that carbon atom was quadrivalent and that one of the four bonds of the carbon atom could be used to join with another carbon atom.

Kekulé published his results in 1858 in his paper "The Constitution and the Metamorphoses of Chemical Compounds and the Nature of Carbon" and in the first volume of his *Lehrbuch der organische chemie* (1859; *Textbook of Organic Chemistry*).

Kekulé had admitted that his dreams played a decisive role in articulating his theory of chemical structure of organic compounds. He saw the dream while travelling in a bus in London. He describes his dream in the following words: "During my stay in London I resided for a considerable time in Clapham Road in the neighbourhood of the Common.. One fine summer evening I was returning by the last omnibus…I fell into a reverie, and lo, the atoms were gambolling before my eyes! Whenever hitherto, these diminutive beings had appeared to me, they had always in motion; but upto that time I had never been able to discern their motion. Now, however, I saw how, frequently, two smaller atoms united to form a pair; how a larger one embraced two smaller ones; how still larger ones kept hold of three or even four of the smaller; while the whole kept whirling in giddy dance. I saw how the larger ones formed a chain, dragging the smaller ones after them, but only at the ends of the chain…The cry of the conductor, 'Clapham Road', awakened me from my dreaming, but I spent a part of the night in putting on paper at least sketches of these forms. This was the origin of the structural theory."

Kekulé is mostly known for his work on the structure of benzene. It is said that Kekulé's theory of the structure of benzene is the "most brilliant piece of prediction to be found in the whole range of organic chemistry." In a research paper in French published in 1865 Kekulé suggested that the structure of benzene contained a six-membered ring of carbon atoms with alternating single and double bonds. The empirical formula of benzene was known for a long time but elucidation of its structure

Jacobus Henricus van't Hoff

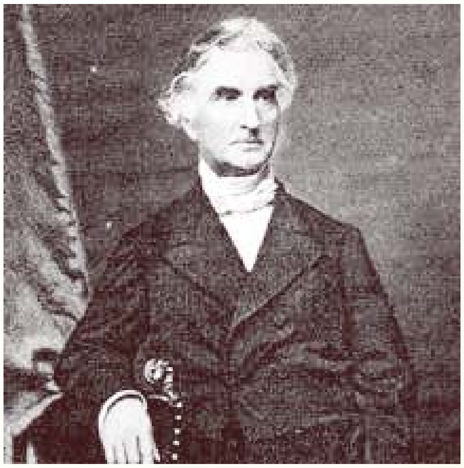
was a real challenge. The problem came from the highly unsaturated nature of the compound. Before Kekulé, Achibald Scott Couper (in 1858) and Joseph Loschmidt (in 1861) had proposed possible structures of benzene. The structures proposed by Couper and Loshmidt either contained double bonds or multiple rings. But the knowledge regarding aromatics compounds was so little that it was not possible for chemists to decide whether any particular structure was correct.

Hermann Emil Fisher

Kekulé successfully demonstrated how organic compounds could be constructed from carbon chains. But there was a set of compounds, which refused to be fall in line. These compounds are called aromatics. Benzene, the first aromatic compound, was discovered in 1825 by Michael Faraday. Benzene had a formula C_6H_6. Taking carbon as quadrivalent atom benzene could not be represented as any kind of chain. The best one could do was to represent it as a chain with alternating single and double carbon bonds but then at the two ends of the chain the carbon atoms were left with unfilled bonds.

Kekulé admits that his dreams helped him to arrive at the structure of benzene. He saw the dream in 1862. Describing his dream Kekulé wrote: "During my stay in Ghent, I lived in elegant bachelor quarters in the main thoroughfare. My study, however, faced a narrow side-alley and no daylight penetrated it…I was sitting writing at my text book, but the work did not progress; my thoughts were else where. I turned my chair to the fire and dozed. Again the atoms were gambolling before my eyes. This time the smaller groups kept modestly in the background. My mental eye, rendered more acute by repeated visions of this kind, could now distinguish larger structures, of manifold combination: long rows, sometimes more closely fitted together; all turning and twisting in snakelike motion. But look! What was that? One of the snakes had seized hold of its own tail, and the form whirled mockingly before my eyes. As if by a flash of lightning I awoke; and this time also I spent the rest of the night in working out the consequences of the hypothesis. Let us learn to dream, gentlemen, then perhaps we shall find the truth…but let us beware of publishing our dreams before they have been put to the proof by the waking understanding."

Here it is interesting to note that a snake with its tail in mouth is an ancient alchemical symbol. It was called Ouroboros. However, to Kekulé this image meant a ring. He realized that if the two ends of the benzene chain then benzene would have a ring structure in which there would be no violation of valence rules. For representing structure of organic compounds Kekulé adopted a graphic form of representation in which univalent atoms were represented by circles and multivalent atoms by figures formed by merging two, three or four circles Kekulé's representations were called 'Kekulé sausages'. Kekulé's system of representation was quite cumbersome and



Justus von Liebig

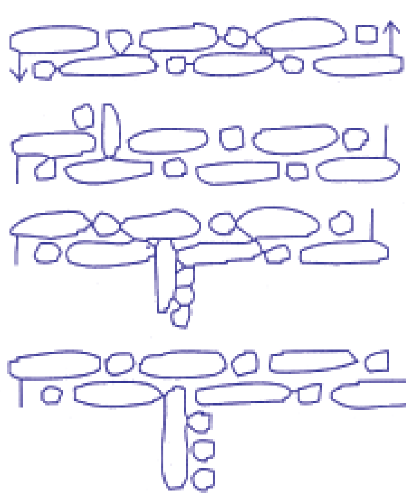
he himself dropped it in favour of the method adopted by the British chemist Alexander Crum Brown (1838-1922). Crum Brown's structural formulae were first introduced in his MD thesis, "On the Theory of Chemical Combination" (1961), which were taken up by Frankland in 1866.

As an evidence for the correctness of his structure Kekulé argued that with his structure it was possible to explain the number of isomers observed for derivatives of benzene. It was known that for every mono-substituted derivative or mono derivative C_6H_5X (where X = Cl, OH, CH_3, NH_2, etc.) there exists only one isomer. This implied that all six carbon atoms were equivalent and so whichever H atom is replaced by any other atom or group of atoms, would lead to only one isomer. Kekulé's structure supported this view. For a di-substituted derivative three isomers were found. The existence of three isomers of a di-substituted derivative or di-derivative was explained by Kekulé by proposing structures with the two substituted carbon atoms separated by one, two and three carbon-carbon bonds. Kekulé's structure proposed in 1865 had a problem in explaining the possible isomers as pointed out by one of his former students Albert Ladenburg. According to Ladenburg with this structure one could visualise two distinct "ortho" derivatives depending on whether the substituted carbon atoms are separated by a single or a double bond. In reality there is only one ortho derivative. To overcome this problem Kekulé modified his structure in 1872. He proposed that the benzene molecule oscillates between two equivalent structures and while doing so the positions of single and double bonds are continually interchanged. This way all six carbon-carbon bonds could be considered equivalent as each bond is single bond half the time and double bond half the time. In 1948 Linus Pauling replaced Kekulé's oscillating model by the concept of resonance between quantum-mechanical structures.

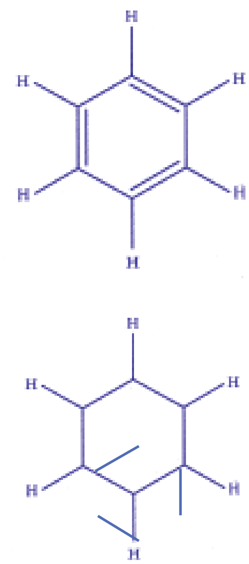
Kekulé's student Van't Hoff translated many of Kekulé's structural ideas into three dimensional models which helped to clarify much of organic chemistry including the existence of optical isomerism.

Kekulé did not firmly believe in the existence of atoms. In 1867, he argued that the existence of atoms "has but little significance from a chemical point of view; its discussion belongs rather to metaphysics. In chemistry we have only to decide whether the assumption of atoms is a hypothesis adapted to the explanation of chemical phenomena."

Kekulé died on July 13, 1896 in Bonn, Germany.



Kekulé's structure of benzene and its derivatives



Molecular structure of benzene

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(The article is a popular presentation of the important points on the life and work of August Kekulé available in the existing literature. The idea is to inspire the younger generation to know more about Kekulé. The author has given sources consulted for writing this 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.)

Nanotechnology in Computer Evolution

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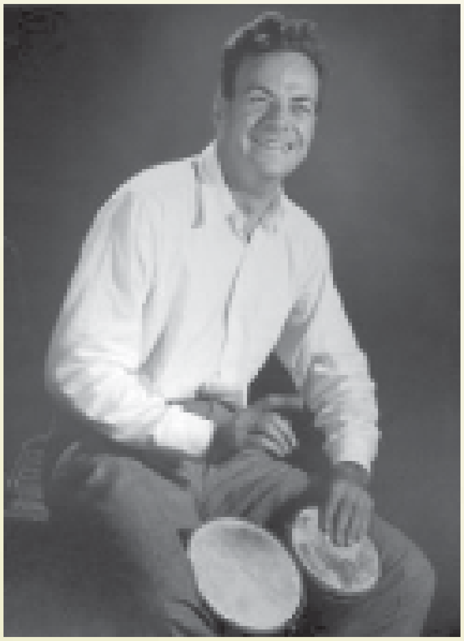
The word nanotechnology specifies those technologies which are based on nanomaterials. In turn a nanomaterial refers to a material produced in nanometre size (10^{-9}). (Just to get an idea of how many atoms there can be in a nanoparticle, a rough estimate tells us that a particle of 3nm diameter contains about 1,000 atoms. Yet another way to visualise a nanometre is to think of it as the millionth part of the tip of a needle, which we are all familiar with. When a material is prepared in this size its properties undergo drastic changes, which in turn can be utilised to develop new technologies.

This possibility was first visualised by Richard Feynman, the great visionary and Nobel Laureate in Physics. He propounded the idea in a lecture delivered at Caltech on 29 December 1959 entitled "There is plenty of room at the bottom". In this lecture he simply emphasised that a length of 1mm when divided into cells of one nanometre size will have one million cells, and argued that if one places objects into these cells and shuffles them around, it will give enormous possibility of different configurations which can be used for storing information. If this is done then the entire contents of all the volumes of *Encyclopedia Britannica*, he said, could be stored in a volume of the size of a pinhead. Therefore he is credited as the inventor of nanotechnology, even though the word as such was non-existent at that time.

Basics of computers

For proper functioning a computer should have the capability to (i) store large amounts of information, (ii) retrieve the stored information as quickly as possible, (iii) transfer the retrieved data to the processing unit fast, and (iv) finally process the data as per the requirement of the user. All these functions are embedded in the Central Processing Unit (CPU) of a personal computer (PC) system. Of course, one also requires a keyboard for data feeding, and a monitor for display. Accordingly, a modern day computer is equipped with a CPU which consists of a hard disc for data storage; a hard disc drive with a 'read' head for quick retrieval of the stored data; a fast processor to process the data as per the demands of the user; and of course the interconnects to carry the retrieved data from the hard disc drive to the processor. For improving the performance and speed it is essential to improve the quality of all these four components of the computer.



Richard Feynman

Over the years all these four components have gone through the process of evolution which is heading the nanotechnology way. The transition from vacuum tubes to solid-state electronics was the key step in the process of this evolution, which helped reduce the size of the computers considerably. The next big step was the replacement of the transistors by integrated circuits where a large number of electronic devices, such as transistors were incorporated within a single silicon chip. The integration subsequently paved the way for Very Large Scale Integration (VLSI) design. Further growth of VLSI followed the so called Moore's law. Each step of this evolution was associated with a reduction in the size of the devices required to be integrated within the chip, which in turn enabled increase of the number of devices on the chip. As per Moore's prediction the number of devices on a chip doubled every eighteen months to two years starting from the year 1965, when he made this conjecture. This prediction has not failed so far, raising the status of the conjecture to a law. The number of devices on a chip has already touched the one billion (10^9) mark, attained towards the end of 2007. With the number of devices per chip touching the one billion mark the size of each device has rapidly decreased to reach around 20 nanometres (nm). So the present day processor manufacturing is already well within the realm of nanotechnology. The production of Pentium IV chips requires all the intricacies of high end technology of etching and lithography required for printing the circuitry within them.

Similarly, the present day magnetic hard discs which store the information also comprise of a few nanometres-thick films of some suitable soft magnetic material, with nanometre-square sized magnetised areas, which are expected to reach the record high 100 gigabits per centimetre-square information storing capability by the end of 2010. For fast retrieval of information the hard disc drive makes use of the physical phenomenon of giant magnetoresistance (GMR), which is a property inherent to magnetic multilayer, as discovered not too long ago. These manmade materials are alternating magnetic metallic and non-magnetic metallic layers each a few nanometres in thickness. Thus the hard disc and the hard disc drive are again well within the purview of nanotechnology.

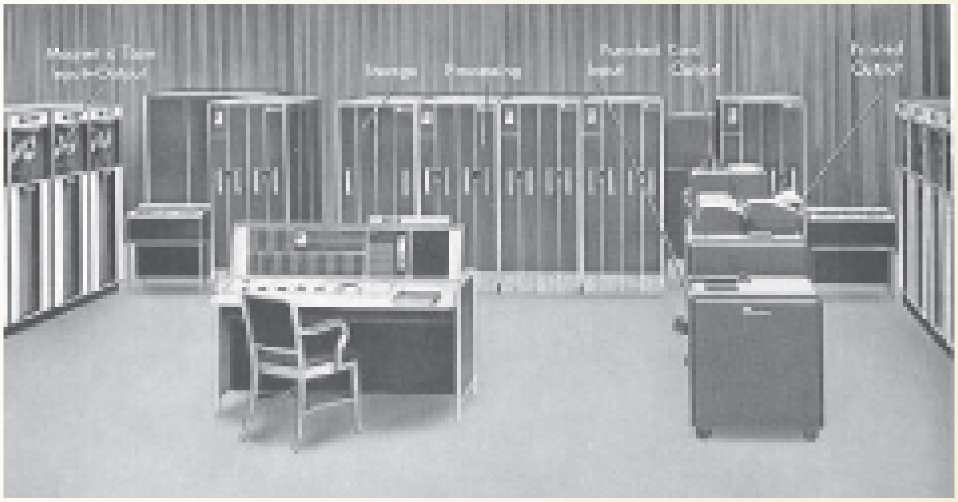
As pointed out earlier, to achieve higher processing speed and performance of the computers it is not enough to pack a large number of devices into a small area of the processor, or store and retrieve large amounts of information using suitable hard discs and hard disc drives. A third ingredient which plays an equally important role in achieving the desired result is how quickly one can carry the information from the hard disc drive to and across the processing unit, which may require only a few centimetres of length to be covered. This is the problem of interconnects, which at present constitute the stumbling block in the path of progress, and the question is how to overcome it. In what follows we shall try to elaborate on some of these problems a bit more in detail.

Miniaturization of the computer

The processor

The first big step in the process of miniaturisation of the computer processors is the shift of the electronics technology from vacuum tubes to solid state devices like transistors. The latter is an outcome of the discovery of semiconductors in 1948 which in turn is a byproduct of the development of quantum theory in the early decades of the 20th century. These developments helped in reducing the size of the computers considerably, as well as in cutting down the cost of their operation due to the low power consumption of transistors as compared to vacuum tubes.

In order to make them functional it is necessary to connect a large number of transistors in a circuit. However, the process



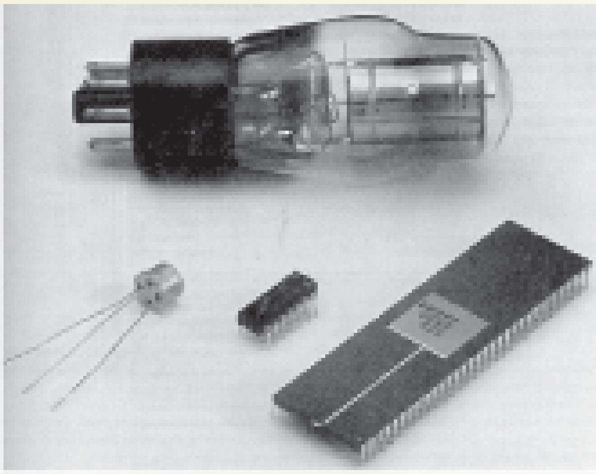
IBM 7080 / 7090 - a prototype of early computer. (Source: www.nordhornantiques.com/vintage computers.htm)

of connecting a large number of transistors for the mass production of computers is cumbersome and makes use of several kilometres of metallic wires which dissipate energy when an electrical current flows through them. So, it was essential to find an alternative method of mass production of the transistor circuitry. The breakthrough was provided by a young electrical engineer named Jack Kilby who had just joined the Texas Instruments company. Since transistors are built out of semiconductors, he argued, why not put them on a single piece of semiconductor and interconnect them by putting a metallic film between them? He made a device by putting five transistors on a single piece of germanium crystal and successfully demonstrated that

Modern personal computer (PC) and laptop.

the idea worked. Thus the technology of integrated circuitry was invented. Kilby shared the Physics Nobel Prize with two others Zhores I Alferov and Herbert Kroemer in the year 2000 for this discovery. The citation by the Nobel foundation quoted that the award was given to the inventors in recognition of their work which laid the foundation of the modern 'Information Technology' (IT). In recognition of the importance of the invention of the 'chip' Kilby received half of the prize money while other half was equally shared between Alferov and Kroemer for developing semiconductor heterostructure which finds use in high-speed electronics and optoelectronics.

The next step was to integrate these devices on a single silicon chip. The technology of printed circuitry was developed further using lithography to incorporate Very Large Scale Integration (VLSI) design and architecture. This again was a major technological breakthrough, which paved the way for further miniaturisation of computers. To start with, many hundreds of devices were incorporated onto a chip of the size of a square centimetre, or roughly of the size of the area of the thumb. Looking at the rapid growth of the number of devices packed on a chip over the years, a computer scientist named Gordon Moore as early as 1965, conjectured that every 18 months to two years the number of devices in a chip is going to double. Since this conjecture has



Comparison of the sizes of a vacuum tube (top) with a transistor and two generations of chips.

not failed till date its status has been raised to that of a law: now known as 'Moore's Law'.

In the first microprocessor introduced in 1971 by Intel Corporation labelled as 4004, there were 2,250 transistors. The other Intel microprocessors were 8008, 8080, and 8086, the last of which was introduced in 1977 and boasted of 65,000 transistors. Subsequently Intel introduced its processor 286 around 1982 which integrated 100,000 transistors. This series of processors ran through 386 and 486, the latter with one million devices was introduced around 1988. Intel's Pentium processor came into existence in 1993 with 10 million devices. Their chip, which finds a place in the CPU of millions of computers today, is the Pentium IV introduced in the year 2000, in which the number of devices had gone up to 550,000,0000. By the end of 2007 it was anticipated to cross the one billion (10^9)mark.

The question that naturally arises in one's mind is "How does one integrate such a large density of devices on a chip?" The technology involves processes like 'masking', 'etching' and 'printing'. The etching and printing is usually carried out using an optical process called 'optical lithography', which utilises visible light. In optical lithography the smallest feature that can be printed depends on the wavelength of the light and limited to half the wavelength. Hence, as the size of the device shrinks with increasing device density, one must use shorter and shorter wavelengths of light, going up to extreme ultraviolet wavelengths. Optical lithography used now in large-scale production to photo-etch the chips is called the 130-nm process. In 2002 Intel introduced a 90-nm process that allows the printing of individual lines smaller than a virus. If extreme ultraviolate light is used the lines in the chip may reduce to smaller than 50-nm size. This account of the development of the chip shows the consistency of Moore's law. With the number of devices per chip reaching the one billion mark, the size of individual devices on the chip has accordingly been shrinking to the present state of about 20-nm. If this trend continues, soon it will touch the limit of the atomic size, where the classical laws of physics which are normally applicable to devices (such as Ohm's law, and other laws of electrodynamics) have to be replaced by quantum laws. According to classical physics the electron is treated as a particle, based on which the laws of electrodynamics are derived. But according to quantum mechanics the electron has a dual nature and behaves both like a particle and a wave. At atomic sizes of the devices, the 'de Broglie' wavelength of the electron will be comparable to the size of the device, paving the way for the observation of the quantum effects. Hence there is a need for exploring the properties of the devices at nanometre sizes. This automatically takes us to nanotechnology in the processor development of computer science.

Jack S. Kilby (left) and a modern chip.

The hard disc

Next to the processor the most important component of a computer is the information storage system. The data can be stored in digital form using any two-state device; that is, a device having an 'on' and an 'off' state so that these states can represent the binary (1 and 0), which in turn can form the code for storing the information. The next question is "How does one produce a two-state device?" Any semiconductor device like a transistor which allows an electrical current to flow through it when switched on, is one such device. A current flows through it in the 'on' state and no current flows in the 'off' state. Such devices can be used for data storage.

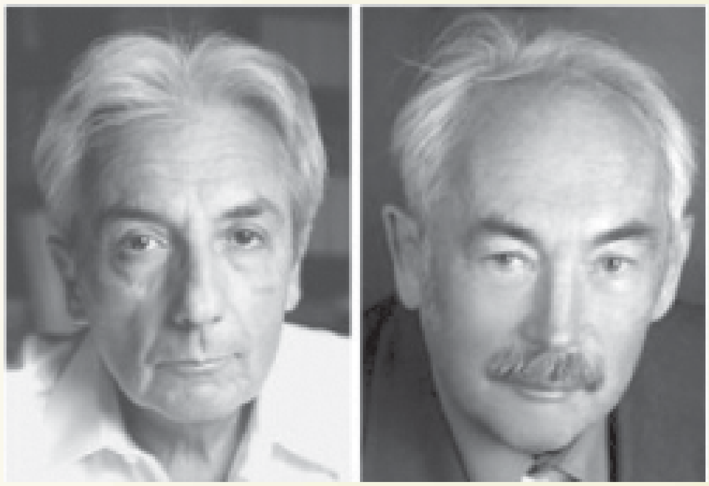
However it was soon realised that data storage using semiconductor devices has a disadvantage. If the power goes off at any instant of time then all the stored information is lost. Therefore, the computer memory built out of transistors is 'volatile' in nature. Such volatile "Random Access Memories" (RAM) are only for limited use. Hence, one needs some memory elements which are 'non-volatile' in nature. This can be achieved by using magnetic materials, which can be magnetised easily and whose axis of magnetisation can be rotated easily. Such 'soft' magnetic materials can be used to make "Magnetic Random Access Memories" (MRAM), where the information can be stored by magnetising tiny pieces of the material such that alternating areas are either of finite or zero magnetisation or magnetised in two different directions, so that these can represent the binary states for storing information. The great advantage of MRAM is that it is non-volatile, since switching off the power does not affect the magnetisation.

In early days magnetic tapes were used to store the information. Such magnetic tapes usually had a uniform thin coating of a magnetic material over a thin plastic film to provide it with the required flexibility. As a result the density of the magnetic material was low, which affected the life of these tapes, leading to the possibility of loss of the stored information. Therefore the magnetic tapes were soon discarded in favour of magnetic hard discs which have a higher density of magnetic material and are sturdier. One of the magnetic materials, which has the required property and is suitable for making magnetic hard discs is called "Permalloy", an alloy of 20% Iron (Fe) and 80% Nickel (Ni), that is ($Fe_{20}Ni_{80}$) In order to miniaturise the hard disc one must use thin films of Permalloy of nanometre thickness and magnetise tinier and tinier areas. But then the magnetisation also becomes weaker and weaker. The capacity of such magnetic hard discs has been increasing enormously over the years and is expected to touch the 100-gigabit limit by the year 2010. At such capacities of the hard disc the magnetised areas are expected to be only a few nanometres square, with extremely feeble magnetisation. The problem was how to detect such low magnetisation? This brings us to the realm of the technology involved in magnetic read heads and the hard disc drives.

The hard disc drive and read head

It is just not enough to attain the capability to store huge amounts of information. For the efficient functioning and speed of a computer, it is also essential to quickly retrieve the stored data. This requires a proper 'read head' for the magnetic hard disc.

Information stored in a magnetic tape or hard disc can be read by using some electromagnetic property which can effectively detect the magnetisation. One such property is based on Faraday's laws of induction, according to which when a coil made of a conducting wire is brought near a magnetised object a current will flow through the coil. Thus by measuring the current through the coil one can sense the magnetisation and its strength. So in the beginning a coil was used as the read head to retrieve the information stored in magnetic tapes. However, as the magnetised area in the tape became smaller and smaller, the strength of magnetisation to be detected became weaker, resulting in very feeble currents in the coil. This puts a limit on the measurement of the current, which in turn restricts the size of the magnetised area in the storage medium. As a result the capacity of the hard disc for storage of data gets restricted. Instead of making use of the induced current in the read head to sense the magnetisation, if one could identify some other property, which can be used to make a more sensitive detector of the magnetisation then the efficiency of the read head can be increased, thus simultaneously increasing the data storage capacity of the hard disc. Such a property which can find use as the detector of magnetisation is the phenomenon of 'magnetoresistance' (MR).



Albert Fert (left) and Peter Gruenberg (right) the 2007 Nobel Laureates in Physics.

Magnetoresistance is nothing but the change in electrical resistance of a metallic wire or a strip in the presence of an external applied magnetic field. This is not a new effect, but was known to the physics community for almost the last 150 years. The effect was discovered by Lord Kelvin in 1856. As is well known the electrons which carry the electrical current in a metal, get scattered or deviate from their original path when they encounter the impurity atoms and other defects as well as the 'phonons' (the quanta of thermal lattice vibrations) present in the metal. This results in the intrinsic resistance of a metal to the flow of current. When an external magnetic field is applied the electrons carrying the current experience an additional force and instead of moving in a straight line they move in a longer helical path. Because it follows a longer route it is likely to meet more scatterers and hence the electrical resistance to the flow of current also increases. This is the simple explanation of the magnetoresistance observed by Lord Kelvin. Since the resistance in the presence of the magnetic field increases this is termed the positive MR. This however is a small effect; the observed increase in resistance being usually less than 1% of the resistance of the metal in the absence of the magnetic field. Furthermore, this is an anisotropic effect, being dependent on the direction of the applied magnetic field. If the applied magnetic field is perpendicular to the direction of the flow of current then the MR is maximum, while it vanishes if the magnetic field is parallel to the direction of the flow of current. The increase in MR was too small to be of any practical use.

Giant magnetoresistance (GMR)

Here too, the solution emerged in the form of nanotechnology. The breakthrough appeared with the discovery of the phenomenon of giant magnetoresistance (GMR) in the year 1988. The discovery was made by two physicists Albert Fert of France and Peter Gruenberg of Germany, independently and simultaneously. They came up with the discovery while investigating the electrical and magnetic properties of a magnetic multilayer. Soon highly sensitive magnetic read heads were developed using the GMR effect for the retrieval of the data from hard discs. This has pushed the density of the data storage capacity of the hard discs considerably and it is estimated that this will rise to the all time high value of 100 gigabits/cm^2 by the end of the year 2010. For the discovery of the GMR effect and considering the tremendous impact it made on the computer hard disc drive technology, Fert and Gruenberg were awarded the Nobel Prize in Physics for the year 2007. This can be acknowledged as the first Nobel Prize for Nanotechnology.

The problem of interconnects

The process of miniaturisation of the computers in recent years have seen tremendous progress and advancement in the areas of processor, hard disc, and hard disc drive technologies, some of which have been outlined above. However, at present this process has slowed down considerably, because of the problems with interconnects. It is just not enough to have a fast and efficient processor, a hard disc and an efficient read head to be able to store and retrieve huge amounts of information. For the proper functioning of the computer it is also essential that the retrieved information be carried to the processor as quickly as possible using efficient interconnects. At present the information is carried in the form of electrical signals from the hard disc to the processor by metallic (usually gold, silver, and copper) wires of high electrical conductivity. These interconnects are also integrated into the chips in many layers. Considering the number of devices in the chips to which the electrical signals have to be fed from the hard disc drive, the length of these wires in a computer may go up to several thousands of kilometres, as can be seen from a simple estimation. If we take the size of the chip to be a couple of square centimetres, within which there are one billion (10^9) devices considering the average length of an interconnect to each device to be ~0.5cm ($5'10^{-3}$ m) the total length of the interconnects will run to about five thousand kilometres. It should be noted that this estimation does not account for the distance between the hard disc and the processor.

In order to accommodate thousands of kilometres of wire inside the CPU the wires have to be to be extremely thin. Even though metals of high conductivity like gold is used for the interconnects, considering the fact that the wires have to be very thin and their lengths go to the order of thousands of kilometres, the resistance offered by it to the flow of electrical current would be very high, resulting in the generation of enormous amounts of heat and loss of power. If proper care is not taken to cool the computer and dissipate the heat, the density of heat inside the system may rise to very high levels. This creates a design problem, and requires an effective way for the removal of the heat. Information is usually transmitted through a wire by superimposing the signal over an electrical wave of an alternating current so that the modulated wave carries the information. When information is to be transmitted in digitized form, higher a.c. frequencies are usually used. As the size of the devices gets reduced, the electrical wave has to be of higher and higher frequencies in order to carry information in larger quantities and to deliver it at a faster rate. To cope with the requirement of fast transmission of signals the frequency of transmission has gradually gone up from kilohertz (kHz) to megahertz (MHz) to gigahertz (GHz) level. This is what determines the speed of the chip. In fact the Intel i486 processor ran at 25 MHz while the Pentium IV raised it to 2.2 GHz. The predicted one-billion-transistor processor is expected to run at 20 GHz. But, still, these interconnects are not able to keep up with the growth of the number of devices per chip in the processor and the speed with which the hard disc drives are capable of retrieving information in the present day computers. As transistors shrink in size, power consumption and heat generation emerge as obstacles in the path of achieving speed and efficiency if one continues metallic wires as connectors. This explains why interconnects have become the stumbling block in the path of increasing the performance of computers at present.

Photonics

One of the obvious routes to solve the problem of interconnects is to take recourse to "photonics"; that is, instead of using electrical waves to carry the information one can use optical waves to carry the same. Optical waves have two major advantages over electrical waves; firstly these have much higher frequencies and hence can transmit information at a much faster rate, and secondly within a narrow bandwidth of the light that one can use for this purpose, there can be almost an infinite number of waves with slightly different frequencies available because of the continuous distribution of wavelengths within the band. Besides, there is the further advantage that no heat is generated in optical transmission, as light propagates through dielectric wave guides or optical fibres, which do not require flow of electrons. However, despite all these advantages photonics still has not succeeded in replacing the electrical interconnects within a computer.

There are mainly two difficulties which one must overcome before implementing this switchover to photonic interconnects. The first difficulty arises from the fact that the computer industry is based on 'silicon' technology. In order to switch over to photonics, the material out of which the devices are made in a computer chip, namely silicon at present, must be capable of receiving and transmitting optical signals. That is, the material must be a light emitter which silicon is not. Semiconductors like gallium arsenide (GaAs) and gallium nitride (GaN) can receive and transmit electromagnetic radiation. Devices made out of these materials can be optically connected using radiation in the visible region of the electromagnetic spectrum, say, for example, green light. However, changing the base of the computer industry from silicon to an optically active semiconductor will require fresh heavy financial investment, which the industry is not prepared to go into. The alternative for the industry is to find ways of making silicon optically active. There have been attempts in this direction for the past several years, and now it is more or less established that while in the bulk form silicon does not absorb or emit light, when prepared as nanoparticles, it can receive and transmit information through light. When this process is perfected it may be possible to switch over to photonics as interconnects in silicon-based computer technology. Again what emerges as a possible solution is based on nanotechnology.

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Editorial (Contd. from page 2)

inch) telescope constructed in 1789. The largest single telescope for visible and infrared light in the world today is the Great Canary Telescope situated at La Palma, Canary Islands, with the main mirror 10.4 m (410 inches) in diameter. There are plans afoot to build telescopes that are 3 to 5 times larger still.

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

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

In 1923, American astronomer Edwin Hubble, using the largest telescope in existence at the time – the 2.5 m (100-inch) Hooker telescope at the Mount Wilson Observatory – discovered that the Andromeda nebula was a vast distance from the Milky Way Galaxy, which had a diameter of 100,000 light years (a light year is the distance light travels in one year at the speed of 300,000 km/s); and so must be a separate galaxy. His studies of distant galaxies revealed that the universe was not static, as had been previously believed, but was expanding in size.

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

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

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

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

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

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

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

☐ **Vinay B. Kamble**

Letters to the Editor

Critical issues in education

The article 'Science, Technology and Transition to a Knowledge Society' by Professors Agarwala and Nigam (*Dream 2047* October 2008) was very informative. It discussed the critical issues and concerns of the present day education in India and the overall knowledge status. We need to improve the standard of our education not merely for awarding degrees but also for raising the basic level of science teaching. This may be possible through changing the education pattern as one adopted in American universities. Good faculty is often not available, as the cream of the nation opts for professional studies which give them higher income. The proposed UGC pay package may attract meritorious students to science stream and help in improving science education.

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Good article on *Chandrayaan-1*

I am regular reader of your magazine. It has helped increased my awareness about our environment. I read the article on *Chandrayaan-1* (June 2008), which was excellent. The biographies of scientists inspire me to do something for my country. I hope you will continue to provide me such excellent science articles in future.

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Multifaceted magazine

Dream 2047 is a multifaceted magazine covering topics from recent issues in S&T to the recent developments in S&T. To add more charm to the magazine, there should be a regular column on the works of the makers of modern science like Einstein, Heisenberg, Schrodinger, Max Planck, and others.

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2008 Nobel Prizes in Science

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The 2008 Nobel Prizes in the field of science have been shared by nine scientists – four Americans, two Japanese, two French, and a German. The works for which the winners were selected range from highly esoteric field of theoretical physics to the discovery and development of a unique protein found in jellyfish and the discovery of viruses that cause AIDS and cervical cancer.

Physics

The Nobel in Physics for 2008 has been awarded jointly to Yoichiro Nambu of the University of Chicago, USA, Makoto Kobayashi of High Energy Accelerator Research Organization (KEK), Tsukuba, and Toshihide Maskawa of Yukawa Institute for Theoretical Physics (YITP), Kyoto University, Japan. Nambu gets half of the prize money for the discovery of a mechanism called spontaneous broken symmetry in subatomic physics, while Kobayashi and Maskawa shares the other half of the prize money for discovering the origin of the broken symmetry that predicted the existence of at least three families of quarks in nature. According to the Royal Swedish Academy of Sciences, the insights of the three scientists "give us a deeper understanding of what happens far inside the tiniest building blocks of matter." All three scientists were rewarded for work done decades ago.

Nambu's work permeates the Standard Model, which describes the behaviour of elementary particles and three of the four fundamental forces that govern nature. (Gravity, the fourth force, has not yet found a place in the Standard Model – physicists hope that the Large Hadron Collider will help to resolve this problem once it begins operating next year.) His work was also able to provide satisfactory explanation of the diverse nature of the fundamental forces, and the way elementary particles, including the particles that mediate those forces, can have such disparate masses. For example, the top quark is more than 300,000 times heavier than the electron, whereas the photon has no mass at all.

Kobayashi and Maskawa explained broken symmetry within the framework of the Standard Model, but their theory required that the model be extended to three families of quarks. Their explanation correctly predicted the existence of a new family of quarks, which have since been discovered. Kobayashi and Maskawa also predicted that broken symmetry would arise for other particles called 'B mesons'. In 2001, the two particle detectors BaBar at Stanford, USA and Belle at Tsukuba, Japan, both detected broken symmetries independently of each other. The results were exactly as Kobayashi and Maskawa had predicted almost three decades earlier.

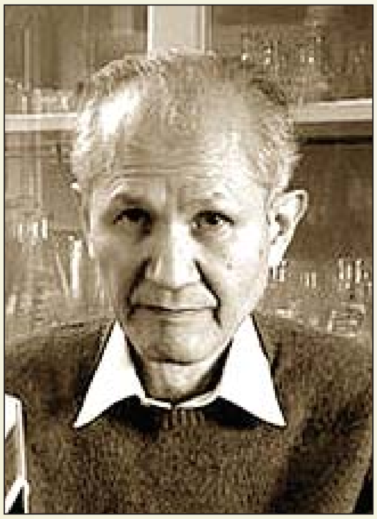
Yoichiro Nambu

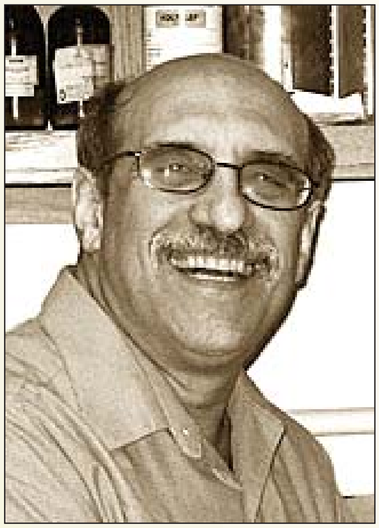
Toshihide Maskawa

Makoto Kobayashi

Chemistry

This year's Nobel Prize in Chemistry has been awarded jointly to three scientists – Osamu Shimomura of Marine Biological Laboratory Woods Hole, and Boston University Medical School Massachusetts, USA, Martin Chalfie of Columbia University, New York, USA, and Roger Tsien of University of California, San Diego, USA for the discovery and development of a brightly glowing substance called green fluorescent protein (GFP) found in the beautiful jellyfish *Aequorea victoria*. Unlike other bioluminescent substances, which need a continuous supply of energy-rich molecules, GFP shows green fluorescence merely on exposure to ultraviolet or blue light. This unique property of GFP has made this protein an ideal substance for researchers for monitoring in real time an ever-increasing number of phenomena in living cells and organisms like gene expression, protein localisation and dynamics, protein-protein interactions, cell division, and


Osamu Shimomura


Martin Chalfie


Roger Tsien

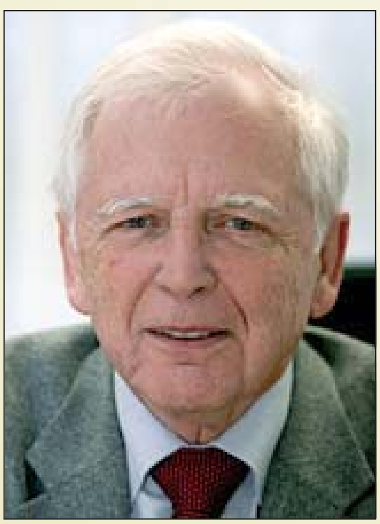
chromosome replication and organisation.

In recent years the green fluorescent protein has also found use in biotechnological applications, including the detection of arsenic in water wells. This is an enormous problem in parts of South-East Asia, where naturally occurring arsenic is poisoning many thousands of people. Researchers have genetically modified arsenic-resistant bacteria that will glow green in the presence of arsenic. Scientists have also modified other organisms to fluoresce green in the presence of the explosive trinitrotoluene (TNT) or heavy metals such as cadmium or zinc.

Physiology or Medicine

The Nobel Prize in Physiology or Medicine for 2008 has been shared by Harald zur Hausen of German Cancer Research Centre, Heidelberg, Germany, Françoise Barré-Sinoussi of Virology Department, Institut Pasteur Paris, France, and Luc Montagnier of World Foundation for AIDS Research and Prevention, Paris, France. Zur Hausen will receive half of the prize money for his discovery of human papilloma viruses that cause cervical cancer, while the other half of the prize money will be shared by Barré-Sinoussi and Montagnier for their discovery of human immunodeficiency virus.

Zur Hausen's suggestion that human papilloma virus (HPV) infection might lie behind cervical cancer was made in the early 1970s, at a time when the general opinion held that another commonly present virus, herpes simplex virus, might be the cause. His realisation that subtypes of a virus that produces harmless warts can also lead to cervical cancer, took a decade of work to prove. By the early 1980s his team found novel viruses in genital warts. Their subsequent identification of two novel HPV subtypes in cervical cancers formed the essential piece of evidence linking HPV infection to the onset of the disease.


Harald zur Hausen


Luc Montagnier


Françoise Barré-Sinoussi

Barré-Sinoussi and Montagnier's discovery of the virus that later came to be known as 'human immunodeficiency virus' (HIV) occurred just two years after the first reports of cases of what we now know as AIDS. An infective agent was suspected by many to cause the disease, and they decided to test whether it might be a so-called retrovirus (any of a group of RNA viruses which insert a DNA copy of their genome into the host cell in order to replicate). Virus production was identified in lymphocytes from patients with enlarged lymph nodes in early stages of acquired immunodeficiency, and in blood from patients with late stage disease. HIV was found to impair the immune system because of massive virus replication and cell damage to lymphocytes. The discovery was one prerequisite for the current understanding of the biology of the disease and its antiretroviral treatment. ■

OSDD — A new paradigm in affordable and Inclusive healthcare

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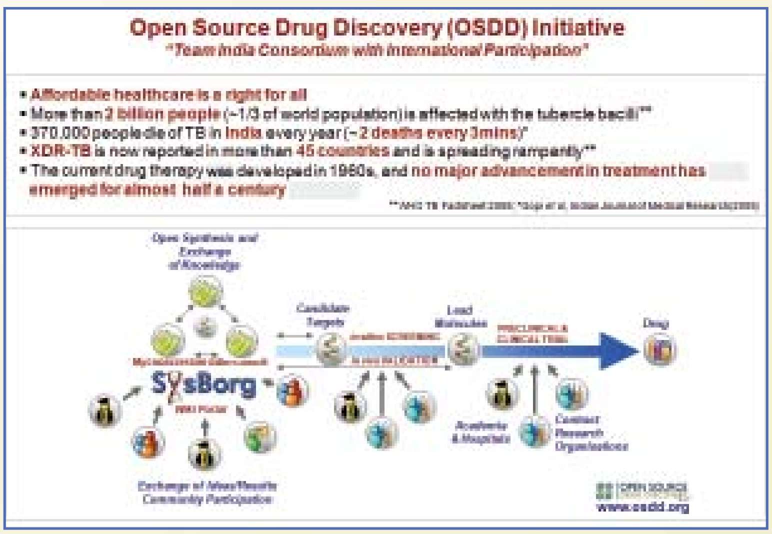
The Council of Scientific and Industrial Research (CSIR) has taken the initiative for an Open Source Drug Discovery (OSDD) project. It is a de-centralised, web-based, community-wide, global effort to provide affordable and inclusive healthcare and is a brainchild of Prof. Samir Brahmachari, Director General, CSIR. The Government of India has committed Rs. 150 crores (US $38 million) and has already released about Rs. 46 crores (US $12 million) towards this project. Further sums will be raised from philanthropic funding, corporate houses and international bodies.

OSDD seeks to significantly reduce the cost of drug discovery by knowledge sharing and constructive collaboration. Its aim is to discover new chemical entities and make them generic as soon as these are discovered, so as to expedite the process of drug discovery. The objective is to significantly bring down the cost of drug discovery and thus, to make drug discovery for infectious/ neglected diseases cost effective and affordable, even for the poorest of the poor. Towards this end, a novel, open source platform for both computational and experimental technologies has been established for delivering the power of genomics and computational technologies into the hands of the talented students, experienced scientists, and motivated technocrats, across the globe.

Modern drugs are expensive because the process of discovery is expensive. The necessity of safeguarding Intellectual Property Rights, confidentiality criteria and overheads etc. substantially raises costs. Pharmaceutical companies therefore zero in on disorders and diseases (such as lifestyle disorders) that stalk affluent countries to guarantee profits. They actively scout the published research papers in their search of new, and potentially lucrative, drug targets. Very few venture into the realm of diseases such as malaria, leishmaniasis, and tuberculosis – the scourge of the Third World.

Market size is a major driving force for new drug discovery programmes. Developing economies simply do not represent the market these companies seek. The discovery and development of a new drug costs approximately US$ 250-800 million and takes about 12 years on an average. For infectious diseases like TB, the market size is only about US$ 300 m – not a lucrative margin of profit, although WHO reports that one-third of the world's population is currently infected and at least one person is newly infected every second. The estimated incidence of TB in India is 1.8 million new cases annually. An untreated active TB patient infects 10-15 people every year. There are two TB deaths every 3 minutes.



The complete genome sequence of *Mycobacterium tuberculosis* – the bacterium that causes TB – was published a decade ago, but TB patients still await a good, fast acting drug, or even a vaccine. There are very few compounds that represent new chemical classes with novel mechanisms of action and a low probability of encountering drug resistance. However, healthcare cannot be only about business; so OSDD aims to make the drugs at low cost for neglected diseases which still cast a dark shadow over many developing countries. It is best to discover/ invent drugs at a low cost because implementing subsidies and controls are not always easy.

The OSDD Way

Registered users of OSDD collaborate through the Internet. They may contribute Intellectual property provided they hold exclusive rights and their action(s) are not in conflict with the policies of their organisation. Any idea/ software/article/molecule that helps in expediting the process of drug discovery is treated as a contribution. The process is divided into Work Packages (WPs) and posted on the OSDD website (http// www.osdd.net). Contributors can select the area(s) of their choice (ex. *in silico* target identification/ protein purification/clinical trials). Students who contribute to OSDD as a part of their projects get certificates as per recommendations of a review committee. Solutions submitted are peer-reviewed. Correct solutions are given appropriate recognition. "Challenges" are also posted on the OSDD website and correct solutions are rewarded appropriately.

OSDD's first target is tuberculosis, which is rampant in developing countries. Let's join hands to say, 'Quit India' to *Mycobacterium tuberculosis*! ■

Alcoholism:

Recognising When You Are Hooked

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> *"There is this to be said in favour of drinking, that it takes the drunkard first out of society, then out of the world."*
>
> *—Ralph Waldo Emerson*

The World Health Organization estimates that nearly 62 million people worldwide suffer from alcohol dependence. The illness implicates a broad cross-section of society and affects people from all walks of life, trapping young students, business executives, artists, journalists, writers, poets, physicians, engineers, skilled mechanics, labourers, and sometimes, even homemakers. The severity of the problem varies in different countries, and the WHO figures probably do not include people in villages and small towns, who live and die with local-made liquor in their circulatory systems. Compared to women, men are many times more likely to become alcoholics, and this probably relates to increased social permissiveness towards alcohol intake in men and, also, the dominant male role in the family. Age also plays its part. The highest rate of alcohol dependence is found in young adults, whereas older people aged 65 and above have the lowest rates.

Environmental factors play a key role in deciding when a person takes to drinking: Parental behaviour, peer influence early in life, life stress, and availability of alcoholic beverages, all affect the drinking pattern. In several societies, abuse of alcohol has become a way of life. When conducting business, people must drink. For many, bars have become an extension of offices, and all key decisions are made there. The pressure to feel and look modern also leads some people to drinking. Women are now taking to alcohol more than ever before, and adolescents are queuing up before liquor shops under increasing peer pressure. The lure of alcohol is also fanned by trendy advertisements of liquor companies. In countries like India, where alcohol advertising is banned, the media plays host to surrogate advertisements with the same end result.

Alcoholism

Response to alcohol also depends upon the frequency and the quantity of alcohol a person drinks. The liver of a habitual drinker starts breaking down alcohol speedily, at 30 per cent faster rate than people who are casual drinkers. Nerve cells of habitual drinkers also develop tolerance, or adaptation towards the structural and biochemical effects of alcohol. These people need to imbibe alcohol in increasingly larger amounts to feel drunk.

Over time, in habitual drinkers, the body's nerve cells become adapted to continuous alcohol exposure, and the structural and biochemical changes that occur in the cells do not return to normal for several weeks. These adaptations form the basis for the body's physical dependence upon alcohol. Nerve cells begin to thirst for alcohol to function optimally. This is called alcohol dependence, or alcoholism. It is a chronic condition marked by a craving for alcohol, and people who are thus afflicted cannot stop drinking even when they suffer serious harm. They experience unpleasant physical complaints, known as withdrawal symptoms, such as nausea, sweating, shakiness, and anxiety if they try to stop drinking. Sometimes, because of alcoholism, they go through serious marital difficulties, job loss, or illnesses, but still cannot stop drinking.

The tell-tale signs of being hooked on alcohol

Alcohol dependence, unless it is checked on time, is a chronically progressive and fatal condition. You find your self often preoccupied with alcohol and cannot control the urge to drink. Despite its adverse consequences, you cannot stop drinking. While you may or may not, most alcoholics deny that there is a problem. The signs of alcohol dependence include:

- Need for drinking alone or in secret
- Not remembering conversations or commitments (alcoholic blackouts)
- Making a routine of having drinks before, with or after dinner and becoming annoyed when this ritual is disturbed or questioned

- Ability to imbibe increasingly more amount of alcohol without becoming incapacitated
- Irritability, tremor, and sweating as usual drinking time nears, indicating the abstinence response
- Keeping alcohol in hidden or unlikely places at home, at work or in the car
- Gulping drinks, ordering doubles, becoming intoxicated intentionally to feel good or drinking to feel normal
- Losing interest in activities and hobbies that used to bring pleasure
- Having problems with relationships, job or finances

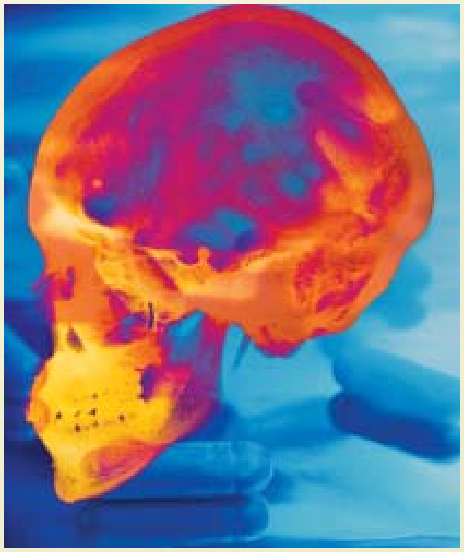
Development of alcohol dependence

Alcohol-use disorders develop in a predictable pattern. There are three stages. Each stage is defined by a set of symptoms that are used in early diagnosis and treatment.

Stage I : Most individuals who drink alcohol do so primarily as an accompaniment to social situations. They are commonly known as social drinkers. Drinking at this stage is not the central focus of a person's activities. If a person remains limited to this stage, he or she generally does not face any problem.

Stage II : A small percentage of social drinkers progresses to stage two. They may not show any signs of illness at first. But with time and continued heavy drinking, they develop severe problems. Activities that focus on drinking take up increasingly larger amounts of time, and as problem drinking progresses the intoxicated behaviour may become disagreeable and antisocial. A person may drink to relieve the physical discomfort of withdrawal symptoms. Most often, attempts to avoid discomfort result in morning drinking to offset symptoms that develop after a bout of drinking the night before.

As drinking continues, drinkers cannot acknowledge that drinking and intoxication have become goals in themselves. Drinking may become a routine for coping with problems, many of which have been brought about by alcohol use itself, often resulting in job loss. Despite the negative cost of drinking, drinkers deny their problem. They continue to claim to friends or family that they can stop drinking any time they want to, but actually they find it increasingly difficult to control their alcohol use.



Stage III: The individual can no longer control his or her drinking and develops the abstinence response, that is, tremor, sweating, wakefulness, and tension soon as the blood alcohol level falls. He or she rapidly develops tolerance and becomes incapacitated until his or her system receives the next dose of alcohol. ■

Treatment Recipes: Overcoming Hangover

Even small amounts of alcohol can cause unpleasant side effects. Some people develop a flushed feeling, whereas others are sensitive to the chemical tyramine found in red wines, brandy and cognac, and develop a splitting headache. The classic hangover probably relates to dehydration, biochemical products formed after disintegration of alcohol, liver injury, and disturbed sleep.

The best remedy for hangovers is to avoid alcohol altogether. But if you have a hangover, take the following advice:

Rest : The simplest and the most practical remedy is rest. Just lie down in the bed and try to relax.

Work at hydrating the body : Drink bland liquids such as water, soda and broth to compensate for the fluid loss.

Avoid irritant stuff : Do not take acidic, caffeinated (tea, coffee, colas) or beverages which contain alcohol. They can irritate the food pipe and stomach, which may already be on fire.

Avoid analgesics : Use of any of the over-the-counter pain medication is fraught with serious risk. It can add insult to injury. The stomach may develop ulcers and start to bleed, or the liver may suffer injury.

Recent Developments in Science and Technology

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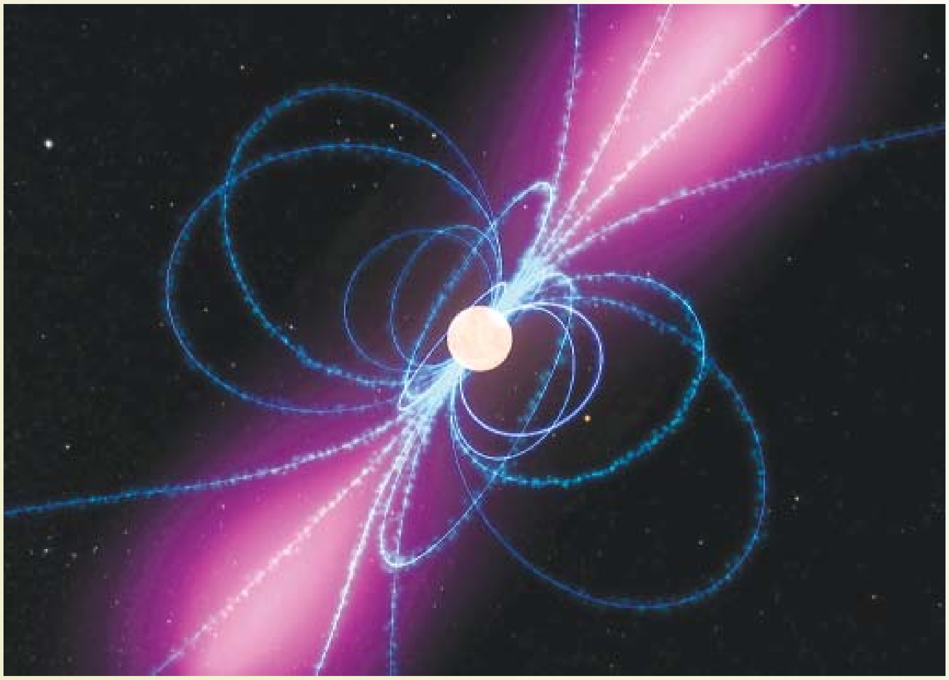
Gamma-ray pulsar discovered

A new kind of pulsars that radiate gamma rays has been discovered by NASA's Fermi Gamma-ray Space Telescope. The gamma-ray-only pulsar lies within a supernova remnant known as 'CTA 1' located about 4,600 light-years away in the constellation Cepheus. Its lighthouse-like beam sweeps across Earth every 316.86 milliseconds. According to NASA scientists, the pulsar, which was formed in a supernova explosion about 10,000 years ago, emits 1,000 times the energy of our Sun. This is the first example of a new class of pulsars.



An artist's concept of the newly discovered pulsar. Clouds of charged particles move along the pulsar's magnetic field lines (blue) and create a lighthouse-like beam of gamma rays (purple).

Pulsars are rapidly spinning neutron stars – remnants of supernova explosions, which is the last stage in a massive star's life. They are compact yet extremely massive – packing the mass of the Sun into a sphere about 20 km across. Whirling around thousands of times each hour, they beam radio pulses into the cosmos in the style of a rapid-fire lighthouse.

The first pulsar was discovered in 1967 by student radio astronomer Jocelyn Bell and her thesis advisor Tony Hewish. The radio pulses they recorded were uncannily steady – so much so that some astronomers wondered if they were picking up signals from extraterrestrial civilizations. Since then, about 1,800 pulsars have been discovered mainly via their radio emission.

In addition to radio waves, some pulsars have been known to emit pulses of visible light, X-rays, and even high-energy gamma-rays, but the newly discovered pulsar is different because it is a purely gamma-ray pulsar. The star does not radiate in other wavelengths of the electromagnetic spectrum where pulsars are normally found. This means that a whole population of previously unsuspected pulsars may be waiting to be discovered.

Did life originate in volcanoes?

More than 55 years ago, American chemists Stanley Miller and Harold Urey of the University of Chicago in Illinois tried to recreate the building blocks of life under conditions they thought resembled those on the young Earth. They passed electric spark discharge through a mixture of reducing gases believed to be present on primordial Earth and came up with a few amino acids, considered basic molecules of life. Miller's findings suggested that life may indeed have been created in primordial seas on Earth by the action of lightning. But Urey and Miller's work is no longer considered valid, as geoscientists today doubt that the primitive atmosphere of Earth had the highly reducing composition Miller used. Theoretical models and analyses of ancient rocks eventually convinced scientists that Earth's earliest atmosphere was not rich in hydrogen.

Recently, on the basis of re-examination of dried residues found in vials of products from the original experiment in Miller's lab the validity of Urey and Miller's experiment seems to have been corroborated. After Miller's death in May 2007, two of his former graduate students – geochemists Jim Cleaves of the Carnegie Institution of Washington (CIW) in Washington, D.C., and Jeffrey Bada of Indiana University, Bloomington – were examining samples left in Miller's lab. They discovered the vials of products from the original experiment and decided to take a second look with updated technology. Using extremely sensitive mass spectrometers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, Cleaves, Bada, and

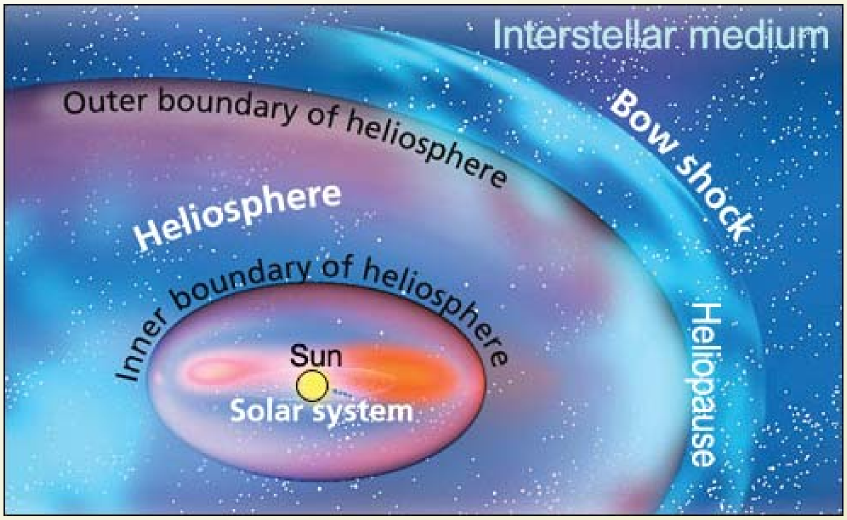
Lightning bolts in the volcanic plume of Chile's Chaiten volcano, which erupted in May 2008.

colleagues found traces of 22 amino acids in the experimental residues. That is about double the number originally reported by Miller and Urey and includes all of the 20 amino acids found in living things (*Science*, 17 October 2008).

According to the researchers, although Earth's primordial atmosphere was not hydrogen-rich, as were the chambers in the Urey-Miller experiment, gas clouds from volcanic eruptions did contain the right combination of molecules. It is possible that volcanoes, which were much more active early in Earth's history, seeded our planet with life's ingredients and bolts of lightning have helped jump-start life on Earth. Reduced gases and lightning associated with volcanic eruptions in hot spots or island arc-type systems could have been prevalent on early Earth. In these volcanic plumes, compounds like hydrogen cyanide, aldehydes, and ketones may have been produced, which, after washing out of the atmosphere, could have become involved in the synthesis of organic molecules, especially amino acids, which in turn, could have been polymerised by carbonyl sulphide, a simple volcanic gas that is known to form peptides under mild conditions.

IBEX mission to study the heliosphere

The Sun constantly gives off a steady stream of charged particles in the form of solar wind, which blows away radially in all directions from the Sun. In the Earth's vicinity the solar wind moves with speeds of 400 km/s; that is, at supersonic speeds. But as it moves outward, the velocity of the charged particles drops. Beyond the orbit of Neptune these supersonic particles slow down as they begin to collide with the interstellar medium and finally stop altogether. In effect, this behaviour of the solar wind causes the formation of a 'bubble' in space that is sustained by the solar wind. This bubble is known as the 'heliosphere'.



The heliosphere moves through the interstellar medium like a boat in water, creating a wave called the 'bow shock.'

Credit: NASA

The point where the interstellar medium and solar wind pressures balance is called the 'heliopause' (*see* figure). In other words, the heliopause is the boundary between the heliosphere and the interstellar medium outside the solar system. The heliosphere moves through the interstellar medium like a boat in water, creating a wave called the 'bow shock,' where the interstellar medium, travelling in the opposite direction, slows down as it collides with the heliosphere.

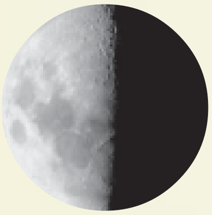
The IBEX probe.

The heliosphere plays an important role in shielding Earth from dangerous cosmic rays. Till date no detailed study of the heliosphere had been made, but a NASA spacecraft is now on its way to carry out a detailed study of the heliosphere. The spacecraft, called '*Interstellar Boundary Explorer*', or *IBEX*, which was launched on 19 October 2008, is designed to image and map dynamic interactions taking place in the outer solar system.

According to the mission scientists, "Just as an impressionist artist makes an image from countless tiny strokes of paint, *IBEX* will build an image of the outer boundary of the solar system from impacts on the spacecraft by high-speed particles called energetic neutral atoms." The neutral atoms are created in the boundary region when the 400 km/s solar wind blows out in all directions from the Sun and ploughs into the gas of interstellar space. The *IBEX* is the first space mission to focus on the heliosphere – the protective bubble that the hot solar wind inflates around the solar system, protecting it from the dangerous radiation in the galaxy beyond. The probe is scheduled to make maps of the region for the first time ever.

Sky Map for December 2008

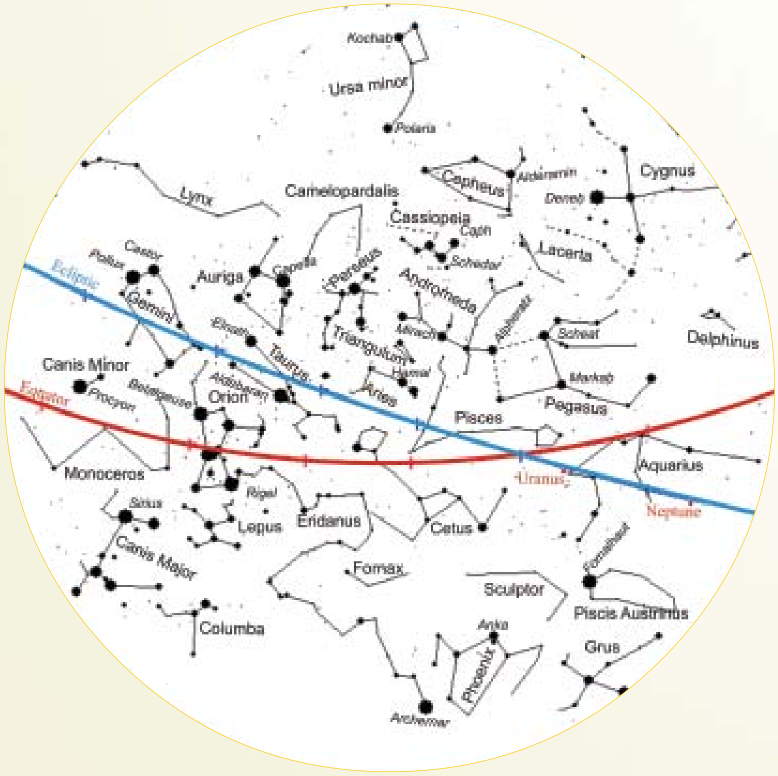
Moon - First Quarter



5 December

North

East



West

South

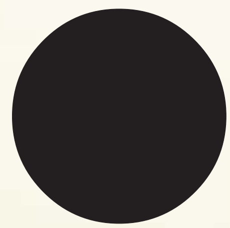
Full Moon

12 December

Moon - Last Quarter

19 December

New Moon



27 December

The sky map is prepared for viewers in Nagpur (21.09^0 N, 79.09^0 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 01 December, at 9:00 PM on 15 December and at 8 PM on 31 December.

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/Dwarf planet round-up :

Uranus : In the constellation Aquarius (*Kumbha Rashi*) up in the western sky*.

Neptune : In the constellation Capricorns (*Makar Rashi*) near western horizon*.

(* Are not naked sky objects.)

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

Eastern Sky : Canis Major (Sirius), Canis Minor (Procyon), Gemini (Castor, Pollux)/Meethun Rashi, Lepus, Lynx, Monoceros, Orion (Betelgeuse, Rigel, Saiph).

Western Sky : Aquarius / *Kumbha Rashi*, Cygnus (Deneb), Delphinus, Lacerta, Pegasus.

Southern Sky : Columba, Eridanus, Fornax, Grus, Phoenix, Piscis Austrinus (Fomalhaut), Sculptor.

Northern Sky : Camelopardalis, Cassiopeia / *Sharmishtha*, Cepheus (Alderamin) / *Vrishaparv,* Ursa Minor (Polaris) / *Dhurva Matsya* (*Dhurva Tara*).

Zenith : Andromeda / *Devayani,* Aries / *Mesha Rashi,* Auriga (Capella), Cetus (Deneb Kaitos), Perseus, Pisces / *Meen Rashi,* Taurus (Aldebaran) / *Vrishabh Rashi*, Triangulum.

□ **Arvind C. Ranade**
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I-YPE 2008: MRP Training Programmes for Eastern and Southern Zone

As a part of International Year of Planet Earth, VP has undertaken an ambitious programme of outreach comprising production of variety software and training programmes across the country. So far about 10 new books, two kits (on biodiversity and weather), a set of 21 posters and CDs have already been brought out. The radio serial *Dharti Meri Dharti* is has been on the air from 7 January 2008 and broadcast from 119 AIR stations. The programme is being broadcast in 19 Indian languages. A 26-episode TV serial will be telecast on the National Channel every Sunday morning beginning 30 November 2008.

A session in progress at NRP Training programme at Guwahati

One of the initiatives taken by VP was to have collaborative programmes and activities with agencies, institutes, and organisations working in the field of science communication. The current initiative is to take up the collaborative programmes to train the master resource persons. Under this programme five zonal level training programmes are being organised in different part of the country. So far two training programmes have already been organised in Guwahati and Bengaluru. The remaining three are scheduled to be held during November-December 2008 at Chandigarh, Bhopal and Ahmedabad.

In all these workshops selected communicators from different voluntary organisations, S&T Councils and coordinators of VIPNET Clubs are being invited. The basic objective of these workshops is to train the MRPs in organising national campaigns on the theme of Planet Earth; to conduct activities related to various sub-themes; and to familiarise them with activities/resource packages produced by Vigyan Prasar like posters, kits, CDs etc.

The first four-day MRP training programme was organised jointly by Vigyan Prasar and NCSTC, DST at Guwahati during 23-26 September 2008 for the north-eastern states and West Bengal. The training programme was attended by participants from different State S&T Councils of North Eastern states, NGOs, VIPNET Clubs and other government agencies. The local partner for this programme was ASTEC, Guwahati.

During the programme lectures on various topics like 'Planet Earth in a Nutshell', 'Life on Earth', 'Ground Water', 'Climate and Weather', 'Natural Hazards', 'Climate Change', and 'Global Warming and Health' were delivered by resource persons. Demonstration of kits developed in-house on Understanding Earthquakes, Biodiversity, and Weather were given by the scientists of Vigyan Prasar. A nature study tour was organised as part of the programme in which participants were taken to a wetland near Guwahati. The wetland "Deepar bill" is one of the Ramsar sites declared by the Ramsar International Convention. During the tour, participants observed and collected samples of flora, fauna and rocks from the site. In the second half, a trip was made to a site where ex-situ breeding of an endangered animal "Pygmy hog" is being done as a multi-institutional effort. Each participant was given a set of ten books brought, a set of 21 posters, a CD on resource material on Planet Earth and three activity kits on Weather, Biodiversity, and Earthquake.

As per the analysis of the feedback received from the participants about the content of the workshop, about 90.48% found it to be both 'useful' and 'easy to communicate', and about 95.24% found it to be 'informative'. 85.71% felt that the training program was user-friendly. Resource material distributed during the meeting was found to be adequate by 80.95% for conducting the programme in the field. All the lectures were appreciated by all and the field visit and demonstration of kit was found to be most interesting part of the training programme by majority of them.

The second MRP training programme was organised by Karnataka Rajya Vijnana Parishat, Bangalore during September 14–17, 2008 for the southern states (Tamil Nadu, Karnataka, Andhra Pradesh, Kerala, Puducherry), Lakshdeep and Andaman and Nicobar Islands. The programme was organised on the same pattern as at Guwahati. About 50 participants representing various S&T based voluntary organisations, S&T Councils, Coordinators of VIPNET Clubs and the groups associated with community radio from the southern states attended the programme. The trends of the feedback were very similar to those from the Guwahati programme.

MRP Training Programme at Bengaluru: Inaugural Session