R.N. 70269/98
ISSN : 0972-169X

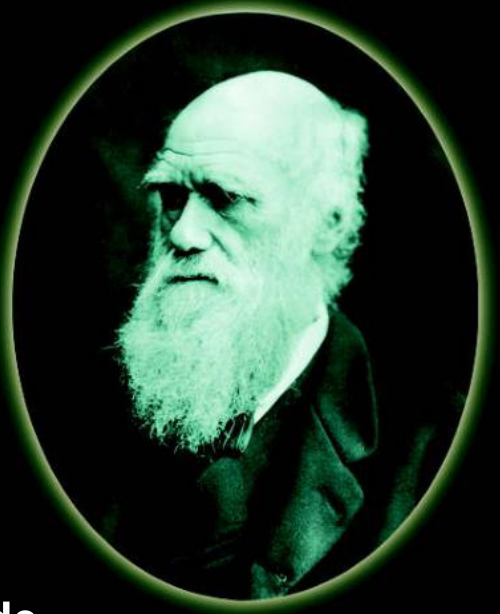
Postal Registration No.: DL-SW-1/4082/09-11
Date of posting: 26-27 of advance month

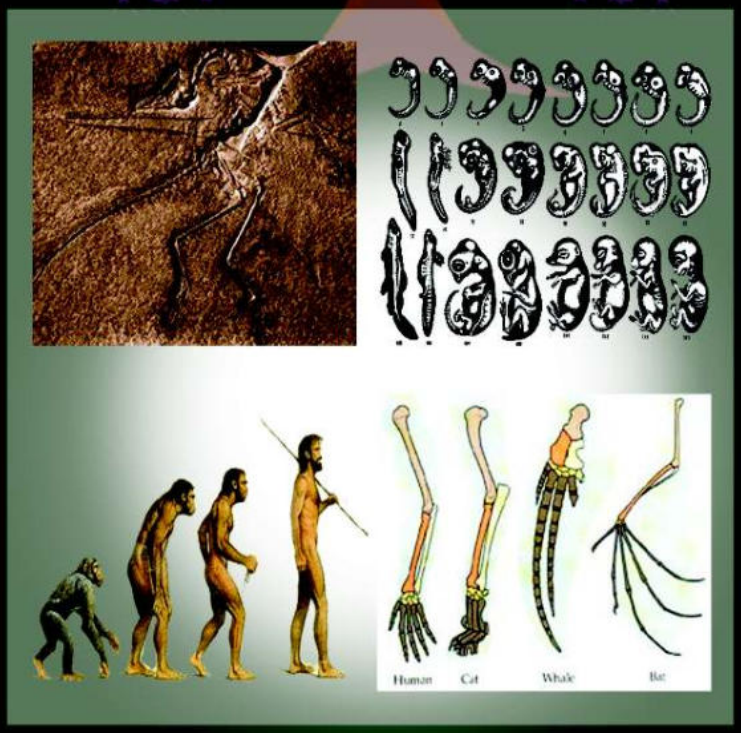
Vigyan Prasar

DREAM 2047

February 2009 | Vol. 11 | No.5 | Rs. 5.00

Darwin's Legacy





Inside

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

Survival of a Theory through Natural Selection

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

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

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

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

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

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

Origin of Species attracted enormous attention to the issue of natural derivation of all species from one, or few, original living forms, or "Evolution" as it is called. In 1871, Darwin came up with *The Descent of Man, and Selection in Relation to Sex,* in which he supported the idea that humans descended from pre-human creatures with considerable evidence from his research. Surely, this was the most troubling point

Contd. on page...26

Editor : **Dr. V. B. Kamble**
Address for correspondence : Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi-110 016;
Tel : 011-26967532; Fax : 0120-2404437
e-mail : info@vigyanprasar.gov.in
website : http://www.vigyanprasar.gov.in

Vigyan Prasar is not responsible for the statements and opinions expressed by the authors in their articles/write-ups published in "Dream 2047"
Articles, excerpts from articles published in "Dream 2047" may be freely reproduced with due acknowledgement/credit, provided periodicals in which they are reproduced are distributed free.

Published and Printed by Dr. Subodh Mahanti on behalf of Vigyan Prasar, C-24, Qutab Institutional Area, New Delhi - 110 016 and Printed at Aravali Printers & Publishers(P). Ltd, W-30, Okhla Industrial Area, Phase-II, New Delhi-110 020 **Editor : Dr. V. B. Kamble**

150th Birth Anniversary

Svante August Arrhenius

Founder of the Electrolytic Theory of Dissociation

Subodh Mahanti
E-mail: subodh@vigyanprasar.gov.in

Arrhenius was a man of wide-ranging intellect. Besides developing his work on solutions, in later life he worked on cosmogony and serum therapy, being especially interested in the relation between toxins and antitoxins. He also investigated the greenhouse effect by which carbon dioxide regulates atmospheric temperature and calculated the change that would have been necessary to have produced the Ice Ages.

A Dictionary of Scientists, *Oxford University Press, 1999*

One of the most important consequences of Arrhenius's theory was the completion of the great generalisations for which the first Nobel Prize for Chemistry was awarded to van't Hoff. Without the support of Arrhenius's theory, that of van't Hoff would never have gained general recognition. The names of Arrhenius and van't Hoff will go down in history of chemistry as making the modern period of this science and it is for this reason that the Academy, despite the fact that experimental basis of the theory of dissociation belongs to physics, did not hesitate to award the Nobel Prize for Chemistry to Arrhenius.

H. R. Tornebladh, President of the Royal Swedish Academy of Sciences
in his Nobel Prize presentation lecture in 1903

Svante August Arrhenius was one of the founders of the science of physical chemistry. He is best known for his theory explaining how solutions of electrolytes (salts) carry electricity, when pure electrolytes or pure water does not. His other major contribution to physical chemistry was his formulation of the dependence of the rate coefficient of a chemical reaction on temperature. This is known as Arrhenius equation. He developed a theory to explain the Ice Ages. He foresaw the greenhouse effect. He worked in diverse fields including immunology, geology and cosmic physics. He proposed that the solar system was created by interstellar collision.

Arrhenius was born on 19 February 1859 in Wijk (also spelled Wik or Vik) near Uppsala, Sweden. His ancestors were farmers. His parents were Svante Gustaf Arrhenius and Carolina Christina Arrhenius neé Thunburg. The family moved to Uppsala in 1860. Arrhenius' father was a land surveyor working for the Uppsala University.

Arrhenius entered the local cathedral school at the age of eight. Even before entering the school he had learned to read on his own. He was not only the youngest in his class but also the brightest. He passed from the school in 1876 and joined Uppsala University in, where he studied physics, chemistry and mathematics.

Arrhenius narrated an interesting episode of his student days to Hubert Alyea, who had worked with him. One day when he was working in the laboratory Arrhenius was given a vial of liquid to dispose of by a senior colleague. The vial contained mercaptans, substances with highly disagreeable odour. Arrhenius had no idea about the nature of the contents of the vial and he kept it in his bag. On his way home on a bicycle he remembered that he had forgotten to dispose the vial properly in the laboratory. He threw the vial on the roadside. In the process of throwing, the vial's cap became loose and the mercaptans evaporated rapidly and spread in a wide area of the town. While people living in the area became aware of the unpleasant smell, they could not locate its source. A committee was appointed to find out the cause of the problem. After prolonged deliberations spanning over several weeks the committee came to the conclusion that unusual meteorological conditions had caused mercaptans to form and that it was very unlikely to happen again. Arrhenius of course knew about the real cause of the problem and he made it sure that it did not happen again!

Svante August Arrhenius

For pursuing his doctorate degree Arrhenius went to Stockholm to work at the Physical Institute of the Swedish Academy of Sciences under the physicist Erik Edlund (1819-1888). In the beginning, he assisted Edlund in his work on electromotive force measurement in spark discharges. However, soon he moved to a problem of his own interest.

He focussed on the conductivities of electrolytes. At the time it was known that solutions of certain compounds called electrolytes conduct electricity and that chemical reactions could occur when electric current was passed. He wondered what property of a compound determined whether it would conduct electricity when dissolved in water or not. He thought that it was the structure of the compound that was responsible.

Arrhenius proposed that when dissolved in water the electrolytes get dissociated into electrically charged particles, or ions, which were the carriers of electricity. It may be noted that it was the great experimental scientist Michael Faraday (1791-1867) had coined the term 'ion' many years earlier. Faraday even thought that ions were produced during the process of electrolysis. But Arrhenius proposed that even when there was no current flowing through the solution, electrolytes were dissociated into ions. The degree of dissociation was dependent on the nature of substance and its concentration in the solution. He thus proposed that the reactions in solutions were reactions between ions. The true significance of Arrhenius' electrolytic dissociation theory is today universally acknowledged though for strong electrolytes certain modifications were necessary to account for their behaviour. Arrhenius' theory of ionization was central to the development of physical chemistry in its early days. This earned the founders of the discipline and their immediate followers the sobriquet "ionists".

His work was published as *Recherches sur la conductibilite galvanique des electrolytes* ("Researches on the Electrcal Conductivity of Electrolytes", 1884) and it was submitted as his doctoral dissertation. The thesis was barely accepted by the University of Uppsala. Members of the Review Committee for awarding doctorate degree were outraged by the novel ideas put forward by Arrhenius. He was awarded the fourth class, the lowest possible grade, which was simply a bare pass. This was in fact a condemnation of an important and original work, which later enabled its author to win the Nobel Prize in Chemistry. It was not the Faculty of the Uppsala University alone who were sceptical of his work. For example, Oliver Lodge, while describing the theory to the British Association for the Advancement of Science observed that Arrhenius seemed sometimes "to indulge in…manipulation of imaginary data" producing "a confusion" from which emerged so-called theoretical deductions.

Postal stamps on Arrhenius

The Swedish chemist Jöns Jacob Berzelius (1779-1848) had earlier suggested a connection between electricity and chemical affinity but the idea was not further pursued by scientists and it was almost forgotten. So most chemists, particularly chemists of Sweden, were not mentally prepared to accept Arrhenius's ideas.

By the negative reaction of his fellow chemists, Arrhenius was disheartened but not totally demoralised. He sent his work to some of the leading physical chemists of the time including Dutch chemist Jacobus Hendricus van't Hoff, German chemist Friedrich Wilhelm Ostwald, and German physicist Rudolf Julius Emmanuel Clausius, all of whom realised the importance of the work. Ostwald was so impressed that he came to Uppsala to meet the young researcher. He even tried to persuade Arrhenius to join his research group in Riga, Latvia, but Arrhenius could not accept it because of his father's illness.

Currencies on Arrhenius

As an extension of his ionic theory, Arrhenius proposed definitions for acids and bases. According to him acids were substances that produced hydrogen ions in solution. Bases were substances that produced hydroxide ions in solution. He explained weak and strong acids by the concentration of ions, or the percent of dissociation, as we know it today. Later the Danish physical chemist Johannes Nicolaus Brönsted (1879-1947), the English chemist Thomas Martin Lowry (1874-1936), the American physical chemist Gilbert Newton Lewis (1875-1946) and others developed a more general model of acids and bases for non-water solvent systems.

A travel grant for the Swedish Academy of Sciences enabled

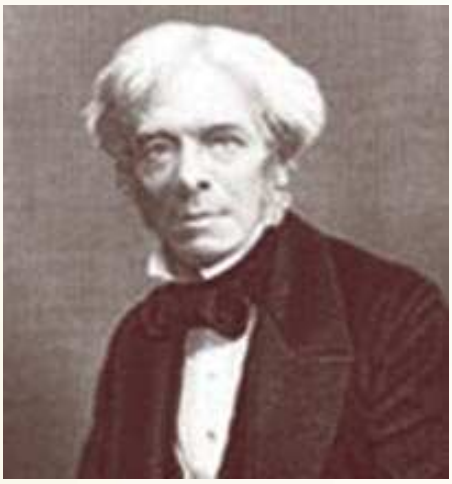
Arrhenius to work with Ostwald in Riga (now in Latavia), Friedrich Kohlrausch in Wurtzburg, Germany, Ludwig Boltzmann in Graz, Austria and with van't Hoff in Amsterdam, The Netherlands.

In 1887, Arrhenius observed that although the gas law (pv = RT) could be applied to the osmotic pressure of solutions, certain solutions behave as if there were more molecules than expected. He thought this was due to dissociation of the compound dissolved in solution into ions. He confirmed his conjecture with further experiments and it was published in 1887 in a paper titled *Uber die Dissociation der in Wasser gelosten Stoffe* ("On the Dissociation of Substances in Water"). Initially many chemists did not favour his proposal that certain compounds dissociated even before the passage of electricity, but the idea has stood the test of time.

In 1889, Arrhenius formulated the concept of activation energy, the energy

Rudolf Clausius

required in order to start a chemical reaction or the energy barrier that must be overcome before two substances reacted. He expressed his idea in the form of an equation known as Arrhenius's equation, $k = A \exp(-E_a/RT)$, where k is the rate of constant of a given reaction and E_a is the activation energy. A is constant for a given reaction called pre-exponential factor. Often the reaction is written in



Michael Faraday

logarithmic form $\ln k = \ln A - E_a/RT$.

In 1891, Arrhenius was offered a professorship by the Giessen University, Germany. However, he declined the offer and took up a position of lecturer in physics the Stockholms Hogskola, a technical institute, which later became the Stockholm University. He was promoted to professor of physics in 1895, though his promotion was strongly opposed. He also served as Rector of Stockholms Hogskola (1897-1905). After his retirement in 1905, he got an invitation to a professorship in Berlin. But he did not accept the invitation because he was made chief of the proposed Nobel Institute of Physical Chemistry to be established by the Swedish Academy of Sciences. Initially the Institute was started in a rented flat but its new building was inaugurated in 1909. A large number of collaborators joined him from Sweden and from other countries. He was a member of the Nobel Committee on Physics since 1900 to till his death. He was also a *de facto* member of the Nobel Committee on Chemistry.

Arrhenius was the first to speculate that there was a link between the levels of carbon dioxide in the atmosphere and the Earth's surface temperature. In an attempt to explain the Ice Ages, he ended up in calculating the temperature changes resulting from the variations in carbon dioxide. He published his results in 1896. He formulated his greenhouse law which stated that "if the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression." He observed that the average temperature of the Earth's surface is about 15 degrees Celsius because of the infrared absorption of carbon dioxide and water vapour. This process is called greenhouse effect. Natural greenhouse effect is the effect created by the Earth's atmosphere in trapping heat from the Sun. He estimated that the reduction of the level of CO_2 to its half would decrease temperatures by 4-5 degrees Celsius, while doubling the level would mean a temperature increase of 5-6 degrees Celsius. [According to the estimates made by the International Panel on Climate Change (IPCC) in 2007, this value is likely to be between 2 and 4.5 degrees Celsius.] Arrhenius thought it would take 3,000 years to

Jons Jacob Berzelius

double the amount of CO_2. It is now predicted that it would take only 100 years. He believed that industrial generation of carbon dioxide would have positive impact because it would protect the globe from recurring Ice Ages and it would also allow increased food production. Today's experience shows that he was not correct. Global warming is rather threatening very existence of life on Earth.

Johannes Nicolaus Brønsted

Arrhenius' belief that life might have carried from planet to planet by the transport of spore gave rise to the theory now called 'panspermia'. He suggested the possibility that radiation pressure would take the living spores from planet to planet.

Arrhenius loved nature. He did not display any interest in art and literature. He proposed the idea of a universal language and suggested modification of English language for this purpose.

Thomas Martin Lowry

Among his important works were *Larobok i teotisk elecktrokemi* ('Textbook of theoretical electrochemistry', 1900); *Theorien der chemie* ('Theories of chemistry', 1906), Immunochemistry (1906); and *Lehrbuch der kosmichen phsik* ('Textbook of cosmic physics', 1903).

He published a large number of books for general public including *Varldarnas utveckling* ('Worlds in the Making', 1906), *Stajanornas oden* ('Destiny of Stars' 1915), *Smittkopporna och deras bekampande* ('Smallpox and its combating', 1913), and *Kemien och det moderna livet* ('Chemistry and modern life', 1919). His popular books were translated in many languages and appeared in numerous editions.

In 1901, Arrhenius was elected to the Swedish Academy of Sciences. In 1903 he was awarded the Nobel Prize in Chemistry "in recognition of the extraordinary services he has rendered to the advancement of chemistry by his electrolytic theory of dissociation." He was the first scientist from Sweden to receive the Nobel Prize. In 1911, he was elected a Foreign Member of the Royal Society of London. He also received the Davy's Medal of the Royal Society (1902) and the Faraday Medal of the Chemical Society of London (1914). He received honorary degrees from the Universities of Birmingham, Cambridge, Edinburgh, Greifswald, Groningen, Heidelberg, Leipzig, and Oxford.

Arrhenius died on 2 October 1927 in Stockholm. He was buried in Uppsala.

References

1. *100 Years of Nobel Laureates*. New Delhi: Encyclopaedia Britannica (India) Pvt. Ltd & I. K. International Pvt. Ltd., 2001.
2. Heilbron, J. L. (ed.), *The Oxford Companion to the History of Modern Science*, Oxford: Oxford University Press, 2003.
3. *The Cambridge Dictionary of Scientists*, Cambridge: Cambridge University Press, 2002.
4. *A Dictionary of Scientists*, Oxford: Oxford University Press, 1999.
5. Bagchi, Asoke K., *Hinduja Encyclopaedia of Nobel Laureates 1901-1987*, Delhi: Konark Publishers Pvt. Ltd, 1990.
6. *Chambers Biographical Dictionary*, New York: Chambers Harrap Publishers Ltd., 1997.
7. Available sources on the Internet.

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

Form IV (see rule 8)

Details of the ownership and other facts relating to monthly newsletter 'DREAM 2047'.

Place of Publication	:	New Delhi
Periodicity of Publication	:	Monthly
Name of the Publisher&the Printer (on behalf of Vigyan Prasar)	:	Dr. Subodh Mahanti
Nationality	:	Indian
Address	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016
Name of the Editor	:	Dr. V.B. Kamble
Nationality	:	Indian
Address	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016
Name & Address of the owner	:	Vigyan Prasar C-24, Qutab Institutional Area, New Delhi-110016

I, Subodh Mahanti do hereby declare that to the best of my knowledge and belief, facts mentioned above are true.

Sd/-

Subodh Mahanti

Darwin's Legacy and Modern Science

Biman Basu
Email: bimanbasu@gmail.com

The year 2009 marks the 200th birth anniversary of the British naturalist Charles Darwin, whose theory of evolution by natural selection became the foundation of modern evolutionary studies. The year also marks the 150th anniversary of the publication of his *On the Origin of Species by Means of Natural Selection* (commonly known by the title *The Origin of Species*) that revolutionised our ideas about the evolution of living beings. Many and diverse were the discoveries made by Darwin in the course of a long and strenuous life, but none of them has had so far-reaching an influence on the science and thought of his time as the theory of selection. Over the past one and a half centuries Darwin's theory has gone through acid tests of critical scientific investigations and has come out with flying colours.

Darwin was born on 12 February 1809 in Shrewsbury, Shropshire, England. At the age of 16 he was sent to study medicine at Edinburgh University, but he later acknowledged that he learned little during his two years at Edinburgh. Nonetheless, he was taught to understand the chemistry of cooling rocks on the primitive Earth and how to classify plants by the modern "natural system." He also learnt how to stuff birds and to identify the rock strata and colonial flora and fauna.

Darwin was admitted to Christ's College, Cambridge in 1828. But here too he spent more time riding, shooting, and beetle-collecting, and managed a 10th place in the Bachelor of Arts degree in 1831. At Christ's College he was shown the conservative side of botany by a young professor, Rev. John Stevens Henslow, while Rev. Adam Sedgwick took Darwin to Wales in 1831 on a geologic field trip. These experiences aroused in young Darwin more curiosity to explore, which was bolstered after reading Alexander von Humboldt's account of the South American jungles in his *Personal Narrative of Travels*. No wonder, Darwin jumped at Henslow's suggestion of a voyage to Tierra del Fuego, at the southern tip of South America, aboard HMS *Beagle*, which was to survey the east and west coasts of South America and continue to the Pacific islands to establish a chain of chronometric stations.

The *Beagle* voyage

Before the voyage Darwin equipped himself with weapons, books (two volumes of *Principles of Geology* by Charles Lyell), and advice on preserving carcasses from London Zoo's experts. The *Beagle* sailed from England on 27 December

Charles Darwin (1809-1882)

1831. It is said that Darwin spent only 18 months of the 5-year voyage aboard the ship; the rest of the time he spent on the ground, pursuing his own interests of collecting and studying local flora and fauna. He made detailed study of animals and plants of the places he visited. When he returned to England in 1836 he was promptly made a fellow of the Geological Society.

Darwin was an avid collector and collected hundreds of specimens from different locations during the 5-year voyage, but he did not quite realise the value of his collection till after he returned to England. For example, when he sailed into the Galápagos Islands in 1835 onboard the HMS *Beagle*, he took little notice of a collection of birds that are now intimately associated with his name. In fact, he misclassified some of the birds that are now known as 'Darwin's finches'.

It took the work of ornithologist and artist John Gould after the return of HMS *Beagle* in 1836 to make Darwin realise the significance of his collection and what he observed during the voyage. Gould made illustrations of a group of preserved bird specimens brought back by Darwin, and announced that the Galapagos birds were not a mixture of wrens, finches, and "gross-beaks," but were all ground finches, differently adapted. The Galápagos Islands was known to have species found in no other part of the world, though similar ones exist on the west coast of South America. From Gould's drawings Darwin identified 13 species of finches in the specimens brought back from the Galápagos Islands. This was puzzling since he knew of only one species of this bird on the mainland of South America, nearly 1,000 km to the east, where they had all presumably originated. He observed that the Galápagos species differed from each other in beak size and shape. He also noted that the beak varieties were associated with diets based on different foods. He concluded that when the original South American finches reached the islands, they dispersed to different environments where they had to adapt to different conditions. Over many generations, they changed anatomically in ways that allowed them to get enough food and survive to reproduce.

"Seeing this gradation and diversity of structure in one small, intimately related group of birds, one might really fancy that from an original paucity of birds in this archipelago, one species had been taken and modified for different ends," he noted in *The Voyage of the Beagle*, published in 1839.

The Origin of Species

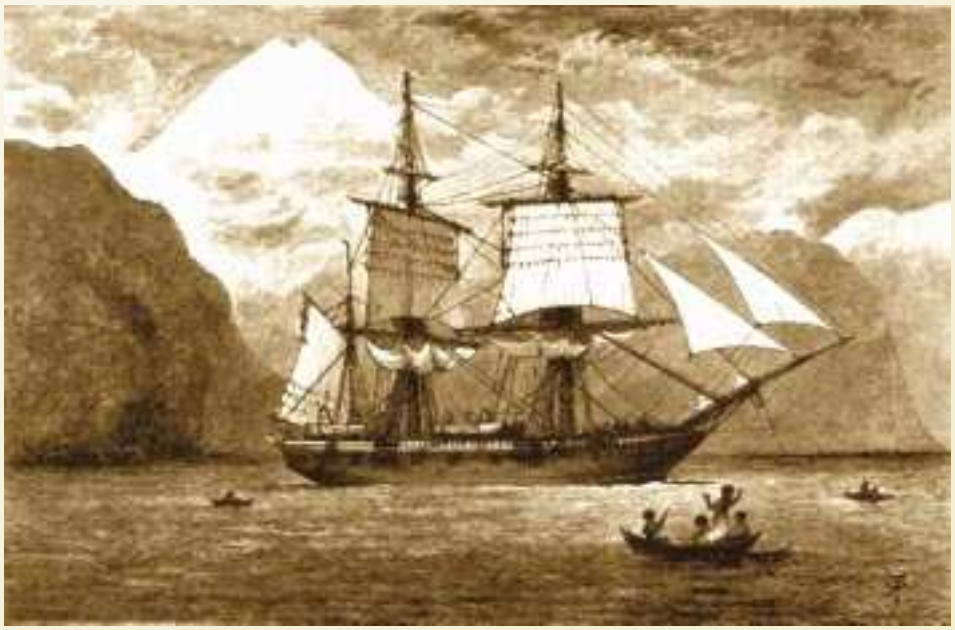
Around this time, Darwin had begun writing a remarkable series of notebooks in which he initiated a set of questions and answers about "the species problem." He began collecting facts about species through letters and discussions with breeders, gardeners, naturalists, and zoo-keepers, as well as through extensive reading. It took Darwin twenty years to translate his understanding of finch adaptation to conditions on different islands into a fully formed theory of evolution in which natural selection could ensure that more favourable traits endured in successive generations. Finally, his famous work *On the Origin of Species by Means of Natural Selection* was published in 1859. In fact, it was rushed to publication in 1859 because another British naturalist and geographer Alfred Russel Wallace had a manuscript that came to virtually identical conclusions. The first edition of the book sold out immediately, and by 1872 the work had run through six editions. Within 20 years it convinced most of the international scientific community that evolution occurred. Darwin had avoided discussion of human evolution in Origin of Species, but his *The Descent of Man, and Selection in Relation to Sex* (commonly known by the title *The Descent of Man*), which came out in 1871, attributed human beginnings to Old World monkeys, which brought severe criticism even from some of his close friends.

Darwin has been described as a great intellectual revolutionary who launched a new era in the cultural history of mankind – an era that was the second and final stage of the Copernican revolution that had begun in the 16th and 17th centuries led by men such as Copernicus, Galileo, and Newton. The Copernican revolution marked the beginnings of modern science. Discoveries in astronomy and physics overturned traditional conceptions of the universe. Darwin's theory has been described as "a foundational pillar of modern science that stands alongside relativity, quantum mechanics and other vital support structures. Just as Copernicus cast the Earth out from the centre of the universe, the Darwinian universe displaced humans as the epicentre of the natural world."

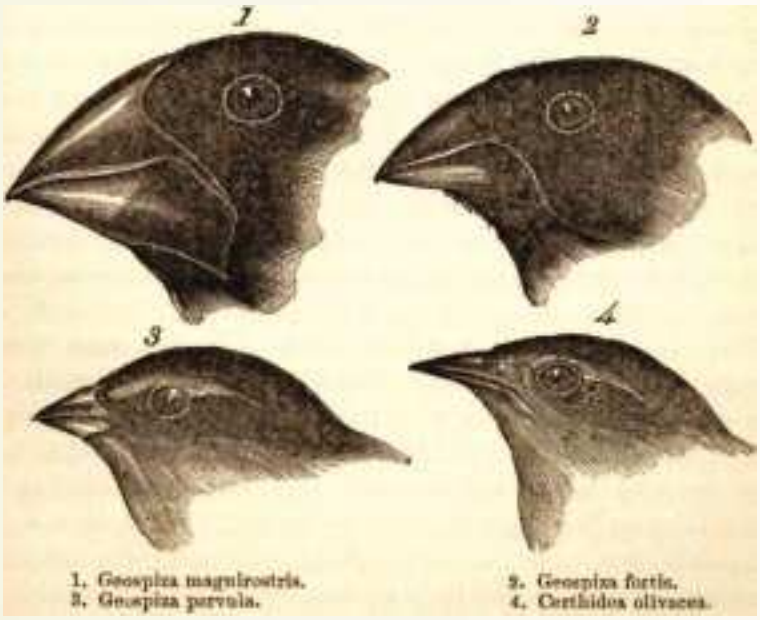
Darwin at the age of 31

Before Darwin, the origin of the Earth's living things, with their marvellous features for adaptation had been attributed to the design of an omniscient God. Similarly, the obvious functional design of animals and plants were attributed to the work of a Creator. Darwin overturned all this in one stroke and provided a natural and logical explanation for the organisation and functional design of living beings, which he did after extensive study spanning several years.

As mentioned earlier, Darwin was not alone in discovering the principle of natural selection; the same idea occurred simultaneously and independently to another British naturalist Alfred Russel Wallace. Wallace and Darwin worked independently, each unaware of the other's research. Yet both developed the same insight into the biological mechanism by which species gradually change by adapting to the particular pressures and requirements of their environment. On 1 July 1858, a year before the publication of *The Origin of Species*, at a meeting of the Linnean Society in London, two papers were read, both setting forth the same idea of selection. One was written by Darwin, the other by Wallace. The two papers, with both Darwin's and Wallace's names, were later published as a single article entitled "On the Tendency of Species to Form Varieties; and on the Perpetuation of Varieties and Species by Natural Means of Selection" in the *Proceedings of the Linnean Society* in 1858. According to an account published in 1909, "It was a splendid proof of the magnanimity of these two investigators that they thus, in all friendliness and without envy, united in laying their ideas before a scientific tribunal." At a time when most people believed that species were the fixed and unchanging product of divine creation, this theory was revolutionary.



HMS Beagle, *the ship in which Darwin sailed on his five-year voyage.*



Darwin's finches

Principle of natural selection

The uniqueness of Darwin's work stems from the fact that he was led to the principle of selection as well as the general doctrine of descent, not through the labours of his predecessors in the early years of the nineteenth century, but by his own observations. He was struck by the innumerable cases of adaptation, as, for instance, that of the woodpeckers and tree-frogs to climbing, or the hooks and feather-like appendages of seeds, which help in the distribution of plants. He believed that an explanation of adaptations was the first thing to be sought in attempting to formulate a theory of evolution by natural selection and he did just that, and he did it meticulously. Further, he gave the theory a form that commended itself to the scientific and public intelligence of the day, and he won widespread conviction by showing with consummate skill that it was an effective formula to work with, a key which no lock refused.

In his Introduction to *The Origin of Species* Darwin wrote, "When on board HMS *Beagle*, as naturalist, I was much struck with certain facts in the distribution of the inhabitants of South America, and in the geological relations of the present to the past inhabitants of that continent. These facts seemed to me to throw some light on the origin of species – that mystery of mysteries, as it has been called by one of our greatest philosophers. On my return home, it occurred to me, in 1837, that something might perhaps be made out on this question by patiently accumulating and reflecting on all sorts of facts which could possibly have any bearing on it. After five years' work I allowed myself to speculate on the subject, and drew up some short notes; these I enlarged in 1844 into a sketch of the conclusions, which then seemed to me probable: from that period to the present day I have steadily pursued the same object. I hope that I may be excused for entering on these personal details, as I give them to show that I have not been hasty in coming to a decision."

He further added, "In considering the origin of species, it is quite conceivable that a naturalist, reflecting on the mutual affinities of organic beings, on their embryological relations, their geographical distribution, geological succession, and other such facts, might come to the conclusion that each species had not been independently created, but had descended, like varieties, from other species. Nevertheless, such a conclusion, even if well founded, would be unsatisfactory, until it could be shown how the innumerable species inhabiting this

Exerpts from *The Origin of Species*

"I look at the term species, as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms."

"Finally, then, varieties have the same general characteristics of species, for they cannot be distinguished from species, except, firstly, by the discovery of intermediate linking forms, and the occurrence of such links cannot affect the actual characters of the forms which they connect;...but the amount of difference considered necessary to give to two forms the rank of species is quite indefinite."

"I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection, in order to mark its relation to man's power of selection. .....But natural selection, as we shall see, is a power incessantly ready for action, and is immeasurably superior to man's feeble efforts,..."

"I use the term Struggle for Existence in the large and metaphorical sense, including the dependence of one being on another, and including not only the life of the individual, but success in leaving progeny."

"A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase."

"Let it be borne in mind how infinitely complex and close fitting are the mutual relations of all organic beings to each other and to the physical conditions of life."

"This preservation of favourable variations and the rejection of injurious variations, I call Natural Selection."

"Under nature, the slightest difference of structure or constitution may well turn the nicely-balanced scale in the struggle for life, and so be preserved."

"It may be said that natural selection is daily and hourly scrutinizing, throughout the world, every variation, even the slightest,... silently and incessantly working, whenever and wherever opportunity offers, at the improvement of each organic being relation to its organic and inorganic conditions of life."

world have been modified, so as to acquire that perfection of structure and co-adaptation which most justly excites our admiration. Naturalists continually refer to external conditions, such as climate, food, etc., as the only possible cause of variation. In one very limited sense, as we shall hereafter see, this may be true; but it is preposterous to attribute to mere external conditions, the structure, for instance, of the woodpecker, with its feet, tail, beak, and tongue, so admirably adapted to catch insects under the bark of trees. In the case of the mistletoe, which draws its nourishment from certain trees, which has seeds that must be transported by certain birds, and which has flowers with separate sexes absolutely requiring the agency of certain insects to bring pollen from one flower to the other, it is equally preposterous to account for the structure of this parasite, with its relations to several distinct organic beings, by the effects of external conditions, or of habit, or of the volition of the plant itself."

The above adequately brings out the conviction Darwin had regarding the process of natural selection, which he later elaborated to explain evolution of species.

The idea of natural selection is quite simple. Some kinds of organisms survive better in certain conditions than others do, and such organisms leave more progeny and so become more common with time. The environment thus "selects" those organisms best adapted to existing conditions. Similarly, if environmental conditions change, organisms that happen to possess the most adaptive characteristics for those new conditions would come to predominate; those that cannot adapt to the new conditions would in course of time become extinct. In spite of this simplicity, however, the theory of natural selection has suffered a long and tortuous history.

Darwin was aware of the opposition his theory of evolution by natural selection would face, especially from those who felt that their religious beliefs required them to reject it. So he tried whenever he could to accommodate religious sensibilities. For example, while describing his theory of natural selection he emphasises not only how much more rational the theory is than the claim that each species was separately created, but argues that it is marvellous and worthy of a majestic creator as well. In the final paragraph he lays down the basic elements of his theory: that individuals in every species tend naturally to vary from the norm, and that when there are so many members of a species sharing an ecological niche that they are competing for survival, only those who whose variations give them decisive advantages would survive and would pass these characteristics on to their descendants.

Evolution and modern genetics

Evidence to support the theory of evolution by natural selection has come primarily from the fossil record, from comparative studies of structure and function, and from studies of embryological development. Besides, long after Darwin had assumed that variations existed, biologists discovered that they are caused by genetic mutation – a change in the genetic material (DNA). This change can be a slight alteration in the sequence of the constituents of DNA (nucleotides), a larger change such as a structural alteration of a chromosome, or a complete change in the number of chromosomes. Random genetic mutations having neither positive nor negative effects were once thought to drive most changes at the molecular level. But recent experiments show that natural selection of beneficial genetic mutations is quite common. Studies in plant genetics show that changes in a single gene sometimes have a large effect on adaptive differences between species. If the change happens in the genetic material in the reproductive cells the result is some kind of structural or chemical change in the offspring. The consequence of such a mutation could

Evolution timeline

610-546 BC

Greek philosopher Anaximander suggests that all life-forms evolved from fish in the seas and went through a process of modification once they were established on land.

1735

Carl Linnaeus publishes the first volume of *Systema Naturae*, which laid the foundations for taxonomy. Later he suggested that plants descend from a common ancestor.

1830

Charles Lyell publishes *Principles of Geology*, a formative influence on Darwin's thinking about the gradualism of natural processes as can be witnessed in the Grand Canyon.

1831

Charles Darwin leaves on a five-year around-the-world journey on the HMS *Beagle*.

1838

Darwin formulates the theory of natural selection, which is not published for more than 20 years. When printed in 1859, *On the Origin of Species* sells out as soon as it is published.

1865

Czech monk Gregor Mendel publishes his research on inheritance, but the importance of his work is not recognised for 35 more years.

1871

In *The Descent of Man*, Darwin ties the human lineage to primate ancestors, provoking outrage in some quarters and the caricaturing of his image.

1936-1947

The modern synthesis combines Darwin's theory of evolution with Mendelian genetics.

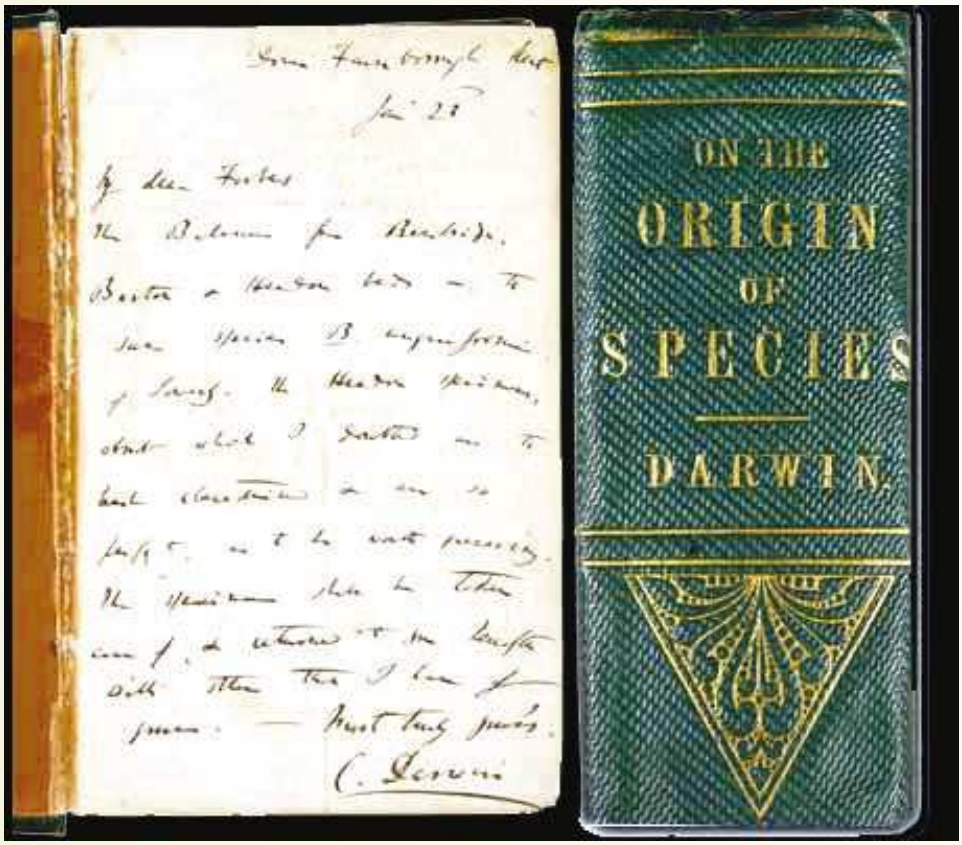
1953

James D. Watson and Francis Crick discover the structure of DNA, making it possible to study the molecular biology of evolution.

Mid-2000s

Genetic analyses show evidence of relatively recent human evolution – dating back several thousand years.

(Source: *Scientific American*, January 2009)



A first-edition copy of On the Origin of Species *(1859) with a letter signed by Charles Darwin on the inside cover.*

lead to the appearance of some feature advantageous for survival, which over several generations could also give rise to a new species.

There is no doubt that Darwinian evolution has been capable of withstanding rigorous tests of scientific scrutiny in both the 19th century and beyond. The idea that nature "selects" favourable variations in organisms was at the heart of Darwin's theory of evolution, but how those variations arise was a mystery in Darwin's time. The unravelling of the DNA structure by James Watson and Francis Crick immediately suggested a possible physical basis for spontaneous variation. Physical damage caused by radiation or other agents or mistakes made in copying the DNA molecule prior to cell division could alter its normal sequence of nucleotides. Such changes or mutations could take many different forms; it may involve substitution of a single nucleotide for another at a particular position in the DNA, deletion of a block of nucleotides, duplication or insertion of new nucleotides, or inversion and translocation of the nucleotides already present. Such changes were still theoretical at the time the structure was proposed by Watson and Crick in 1953. But now large-scale sequencing methods have made it possible to read entire genomes and to study genetic variation with unprecedented detail.

Today investigators, equipped with sophisticated cameras, computers and DNA-sampling tools demonstrate the continued vitality of Darwin's work. Our progress in comprehending the history and mechanisms of evolution has led to powerful applications that shape a wide variety of fields today. For instance, law-enforcement agencies now commonly use evolutionary analyses in their investigations. Knowledge of how different genes evolve determines the kind of information they can extract from DNA evidence. Forensic scientists make use of biologists' understanding of evolving DNA sequences for the powerful tool of genetic markers, which can indicate or rule out links between suspects and crime scene evidence.

In other fields like health care, studies of DNA sequences to infer their evolutionary relatedness of a pathogen such as bird flu or West Nile virus can lead to vaccines and to guidelines for minimising the transmission of the disease to and among people. A laboratory process called 'directed evolution' used in protein engineering to harness the power of natural selection to evolve proteins or RNA with desirable properties not found in nature can improve development of vaccines and other useful proteins. Among other examples, computer scientists have adapted the concepts and mechanisms of biological evolution to create a general system known as 'genetic programming' that can solve complex optimization and design problems. And a recently developed approach known as 'metagenomics' (also known as 'environmental genomics', 'ecogenomics' or 'community genomics') has revolutionised scientists' ability to study of genetic material recovered directly from environmental samples. Traditional microbiology and microbial genome sequencing rely upon cultivated clonal cultures. This relatively new field of genetic research enables studies of organisms that are not easily cultured in a laboratory as well as studies of organisms in their natural environment.

References

1. Seward, A.C. (Ed.) 1909. *Darwin and Modern Science*. (www.gutenberg.org/etext/1909).
2. Darwin, C. 1859. *On the Origin of Species by Means of Natural Selection, or, the Preservation of Favoured Races in the Struggle for Life*. London: J. Murray.
3. Darwin, C. 1839. *The Voyage of the Beagle*. (www.gutenberg.org/etext/3704).
4. 'Charles Darwin', *Encyclopaedia Britannica 2005* (Ultimate Reference Suite CD).
5. 'The Evolution of Evolution', *Scientific American* special issue, January 2009.

New Year came a second late...

TVVenkateswaran
E-mail: tvv@vigyanprasar.gov.in

True. It is indeed a fact. Incredible, unbelievable but that is the real! Anyone who cared to observe keenly would have noticed that on 1 January 2009 at sharp 5:30 a.m. IST one extra second appeared! After 5:29:59 a.m. we had 5:29:60 a.m. and then 5:30:00 a.m. In normal circumstances 5:29:59 a.m. should be followed by 5:30:00 a.m. There is no time called 5:30:60 at all! Such addition of a second is called 'leap second', very similar to addition of a day in the leap year. This was done because; sharp at 5:30:00 a.m. it was 24:00:00 at Greenwich Mean Time. In the clock at Greenwich, 31 December 23:59:59 p.m. was followed by 23:59:60 and then moved on to 0:00:00. So at precisely 23:59:60 at Greenwich, England, on New Year's Eve, there was a one-second void before the onset of midnight and the start of the New Year.

Why do we need to add leap seconds? In the first place why do we need to have leap year? Historically, time was based on the rotation of the Earth relative to celestial bodies. Earth's trip around the Sun is about 365.2422 days long, which we round down to 365. Every four years, during a leap year, the inaccuracy is corrected by adding a day in February.

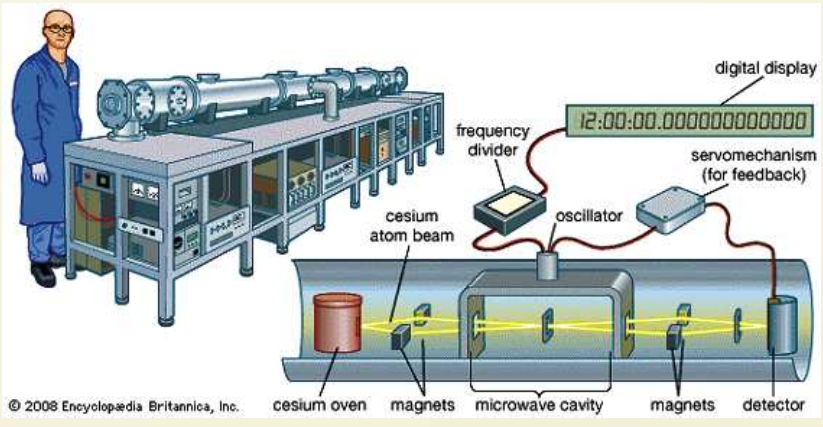
What will happen if we do not add the extra day and kept the year as 365 days uniformly? Say in 400 years we would have lost about 100 days. As a result the seasons would have shifted. Instead of winter in December we would have winter in September and so on. By adding one extra day – February 29 – every four years we keep our calendar in step with the seasons.

The leap seconds are added because the rotation of Earth is not that uniform. In fact, the rotation of Earth is in fact SLOWING down! This happens because during tides, as the Earth rotates, ocean water is dragged across sections of shallow floor and the resulting friction causes the Earth's rotation to slow down. As the Earth slows down another thing happens; the Moon moves faster in its orbit. This is necessary in order to conserve the angular momentum of the Earth-Moon system. But, as the Moon moves faster in orbit it also drifts farther and farther away from Earth at the rate of about 3 cm per year. The 2004 earthquake that caused the killer tsunami also slowed the rotation of Earth by about 3 microseconds.

We know clock time is not same all around the world. When it is morning in India it is night in America. Therefore scientists use the local time at Greenwich as the 'mean time' or standard international time (UTI). Indian Standard Time (IST) is +5:30 hrs. That is, when it is 1:00:00 at Greenwich it would be 6:30:00 IST

Today the atomic clocks are so accurate they lose or gain one second in 200 million years. With such precision measurements, we know that Earth's rotation has been on average falling behind atomic time at a rate of about two milliseconds per day. As a result of this difference, atomic clocks can get out of sync with the Earth and have to be adjusted periodically. The tweak will help correct the time-lag which shows up on ultra-accurate atomic clocks.

Such accurate measurements are not just for fun. They are crucial for the modern world. Mechanisms such as the Internet-based Network Time Protocol and the satellite-based Global Positioning System (GPS) depend on the accurate time kept by atomic clocks. Without having accurate sync between atomic clock and Earth's rotation there will be chaos. As satellite measure the time by atomic clock, their physical position has to match with Earth's rotation. Say if at 24:00:00 by atomic clock the satellite has to be right above Chennai, then it has to be there. If the Earth's rotation has slowed down and satellite is just behind, then one has to adjust the clock and make it sync with Earth's rotation now and then. Otherwise the satellite will be lost. The modern atomic clocks were perfected and time keeping through them began in 1972. An international organisation called Earth Rotation and Reference Systems Service was established at Paris and a master atomic clock is ticking away there. To satisfy the requirements of navigators, communication organisations and scientific groups, about 200 atomic clocks in over 50 national laboratories worldwide have been established. One such clock is there at National Physical Laboratory, New Delhi. All these clocks were adjusted at local times corresponding to midnight at Greenwich on 31 December. Since 1972 it is the 24th time the adjustment has been made. The last was in 2005.



We know that pendulum clocks work by counting the 'vibrations' or oscillations. If the length of the pendulum is one metre then every oscillation (or half period) corresponds to exactly one second. In like manner, atomic clocks work by counting the vibrations made by the atoms. Atoms vibrate very accurately and by counting the number of vibrations one can measure time very accurately. Often caesium atoms are taken up for measurement. 9,192,631,770 vibrations of caesium atoms are taken as one second.

The Hanging Out Womb:
All You Want to Know About

Dr. Yatish Agarwal
e-mail: dryatish@yahoo.com

As the years pass, having borne the rigours of childbirth, a woman's pelvic gear may lose its strength, elasticity and support. As a result the pelvic structures lose their mooring and tend to fall or slip out of place. The uterus, urinary bladder, urethra, and the rectum can give way and hang down.

What causes prolapse

Over time, living through the rigours of life, the once supple and elastic tightly knit pelvic structure loses its holding strength. Going through the travails of childbirth, the ligaments and bands, which hold the pelvic organs in place, lose their strength, get stretched, and can no longer do their job. Devoid of this support, the pelvic organs slip out of place.

The situation may not be very obvious for the first few years, and with younger women. But with the progression of time, it gradually becomes more obvious. Finally, when menopause sets in, the system is suddenly deprived of the normal circulating amounts of female hormones. The ovaries no longer manufacture them.

This further lowers the resilience of the structures and supports that fasten the pelvic organs. Deprived of the female sex hormones, the reproductive organs also undergo a major change in their structure and function. The vaginal canal becomes atrophic. Its lining thins out, and it loses its elasticity and the ability to stretch. The entry sags, the vulva becomes thin and shrinks. Deeper in, the uterine supports similarly continue to lose their strength. The after-effects of the trauma inflicted during previous childbirths are borne by the pelvic tissues, which now no longer have the regular 'oiling up' support that the female hormones provided. The pelvic structures no longer have the support as in the younger years. Also, with the continual stress thrust on them, a continual downward force acts continuously upon them. As the vaginal outlet offers the only release, the pelvic organs take this route. One by one, and bit by bit, the uterus, vaginal walls, urinary bladder and the rectum slip out of their place.

What can go wrong

The urinary bladder, which is located in front of the vagina, tends to push inwards and downwards. This descent of bladder may gradually become quite marked, a condition referred to as *cystocoele*.

As the bladder presses down, a bulging sensation is often felt. This produces a variety of urinary symptoms. The woman finds it progressively more difficult to empty out the bladder. The drooping bladder is perennially left with a small reservoir of urine, which is a fertile ground for infection. Other than this, the urethra (the short tube that conveys urine from the bladder to the exterior) tends to get stretched and suffer irritation. This produces a frequent intense desire to pass urine, although the amount passed is small.

Over time, the valve at the bladder outlet becomes weakened. This produces urinary incontinence. The control over the bladder is lost. Following a simple forceful action such as a sudden cough or sneeze, small amounts of urine may suddenly be released wetting the clothes.

The back wall of the vagina may become weakened. If this happens, the rectum gradually presses in. It bulges inwards and downwards to form a *rectocele*. This descent of rectum may gradually worsen, and produce constipation. In severe degree of rectal prolapse, the prolapsed part may have to be manually pressed back to restore normal bowel function.

All these conditions tend to worsen with time. Due to the weakening of its anchoring supports, and the mechanical pulling of the cystocoele and rectocoele, the uterus is forced down the vaginal passageway.

Severity of uterine prolapse

An early slight descent of the uterus is called a first-degree prolapse. When the uterine neck (cervix) begins to protrude from the vaginal outlet, it is called a second-degree uterine prolapse. When the cervix and the outwardly turned walls of vagina descend so far as to lie permanently outside of the vaginal canal, doctors call it a third-degree prolapse. If it is allowed to remain this way, the protruding part of the womb tends to become rough, dry, atrophic, often ulcerated, and foul smelling and infected. This stage should, however, never be allowed to pass. At the first signs of prolapse, medical help should be taken and a gynaecologist consulted.

Diagnosis

The diagnosis is usually quite obvious. Smaller degrees of uterine prolapse may not be apparent, since the symptoms are generally minimal. Often the woman feels as if something is giving way, or if something is coming down the front passage. These apt descriptions exactly portray the process of prolapse. A pelvic medical examination confirms the findings.

Treatment

The treatment of prolapse is surgical. Vaginal repair operations can rectify the condition. The loose tissues in the front and back walls of the vagina are removed, and the wall is reconstructed. If there is prolapse, the elongated cervix is partially amputated, and with the remaking of the walls of the vagina and strengthening of its supports, the uterus is restored to its natural position.

A number of variations of this theme are available. These surgical operations go by various complex-sounding names, which correspond with the type of surgery performed. These are the names the surgeons talk about, and which you will hear bandied about by women when describing their particular repair operation.

Anterior colporrhaphy

This means the cystocele has been repaired. The front wall of the vagina is reduced in width, and bladder stitched back and a new wall created.

Posterior colporrhaphy

This means the rectocele, or back wall of the vagina is narrowed, the rectum stitched back and the wall repaired.

Manchester operation

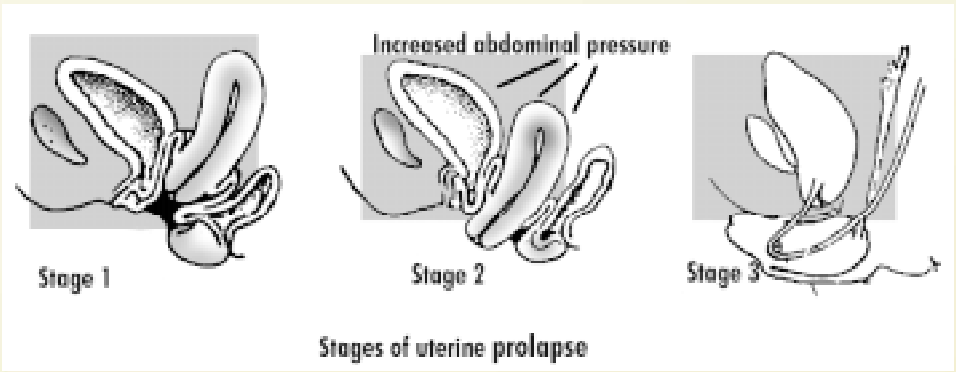
This is a combination of the foregoing two operations. It is the cure for complete prolapse (procidentia), and in addition the cervix is partially shortened in length (for by now it has mechanically elongated). The uterus is stitched back by reinforcing its supports. The vaginal canal is now made more like it was many years before.

Sacrifice of the uterus

Sometimes, the uterus is in such a bad shape that it is best removed. By this time, it has served its useful function and can be easily sacrificed. Various approaches exist. The most common being a *vaginal hysterectomy*, where the uterus is removed via the vaginal route.

Pessaries and rings

In women who are unable to undergo surgery, various medical techniques are used. These rely on mechanical support of the pelvic contents. Pessaries and polythene rings are used for this purpose. However, these are only a second-rate choice, to be considered only when surgery is not possible.



Stages of uterine prolapse

Editorial (Contd. from page 39)

for most people. How could humans descend from a non-human ancestor? Most people, however, accepted Darwin's theory of evolution by natural selection by the end of the 19th century, except for those who opposed evolution as antithetical to the biblical story of creation.

It was around the same time when *Origin of Species* was published that Gregor Mendel discovered the laws of heredity. Working with peas, he found that for each trait, an offspring inherited factors from both the parents equally; and that those factors remain distinct and can in turn be passed on to subsequent offspring. This meant that natural selection would have much more time to operate on any variation in trait.

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

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

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

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

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

Vinay B. Kamble

OBITUARY

C. V. Sundaram (1929-2008)

C. V. Sundaram, distinguished metallurgist and former Director, Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, passed away in the early hours of 15 August 2008 at Chennai.

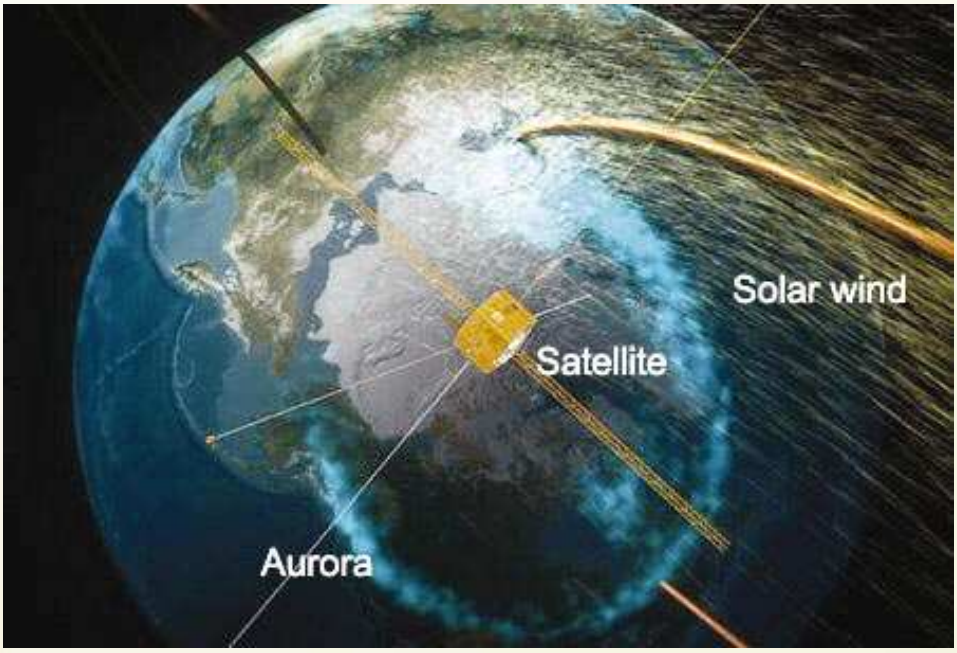
Sundaram was born on 7 November 1929 in Ottappalam, Kerala. Sundaram obtained his B Sc (Hons) in chemistry, with a first rank, from Presidency College, Chennai. He then joined the Indian Institute of Science, Bangalore for his metallurgy degree. After completion of the course at IISc, Sundaram joined the Metallurgy Division, Bhabha Atomic Research Centre, Trombay. In 1982, Sundaram took over the leadership of the Fast Breeder Reactor Programme at Kalpakkam as the Director of the Reactor Research Centre, which was later named as IGCAR, Sundaram was recipient of several prestigious awards. Prof. Sundaram co-authored a book for Vigyan Prasar, "WHERE GODS COME ALIVE : A Monograph on the Bronze Icons of South India."

Recent Developments in Science and Technology

Biman Basu
Email: bimanbasu@gmail.com

Holes in Earth's magnetic shield

The Earth behaves like a huge magnet and the magnetic field that surrounds the Earth like cocoon that protects it from harmful particles coming from the Sun as solar wind – a stream of charged particles spewing from the Sun at 1.6 million km/h – especially during solar storms. The magnetic cocoon diverts the solar wind particles away over the Earth's equatorial and temperate regions. But if the particles are energetic enough, as is the case during severe solar storms, then they can penetrate deeper into Earth's atmosphere. But that happens only around the poles where the magnetic lines of force converge, giving rise to spectacular displays of auroras seen in polar latitudes.



An artist's rendition of one of NASA's satellites flying through a 'crack' in Earth's magnetic field. (NASA)

But it has now been discovered that occasionally holes appear in Earth's magnetic shield. Recent observations made by *THEMIS* (*T*ime *H*istory of *E*vents and *M*acroscale *I*nteractions during *S*ubstorms), a fleet of five small NASA satellites, have revealed the largest hole yet seen in the magnetic field that protects Earth from most of the Sun's violent blasts. Observations from *THEMIS* show the Earth's magnetic field occasionally develops two holes, allowing solar wind to penetrate the Earth's upper atmosphere. The holes are defying many of scientists' previous ideas on how the interaction between Earth's magnetosphere and solar wind occurs: From the location of the holes the whole interaction appears to works in a manner that is completely the opposite of what scientists had thought.

It has been known that the Sun's magnetic field shifts its orientation frequently, sometimes becoming aligned with the Earth, sometime becoming anti-aligned. It was earlier believed that more solar particles entered Earth's magnetosphere when the Sun's field was oriented opposite to the Earth's, but the opposite turned out to be the case here. Data from *THEMIS* showed that twenty times more solar wind passed into the Earth's protective shield when the magnetic fields were aligned.

Using computer simulation scientists have been able to find out how the holes develop. They have discovered that two holes frequently develop in Earth's magnetic field, one at high latitude over the Northern hemisphere, and one at high latitude over the Southern hemisphere. The holes form over the day-lit side of Earth, on the side of the magnetic shield facing the Sun.

This discovery not only has implications for scientists' understanding of the interaction between the sun and Earth's magnetosphere, but for predicting the effects to Earth during the next peak in the solar cycle.

Liquid water on Saturn's moon

New evidence has come of the presence of liquid water on Enceladus, one of Saturn's moons. When NASA's *Cassini* spacecraft swooped past Saturn's moon Enceladus last year, it got a close-up view of the water vapour and ice plumes that stream away from the small moon. But when the velocity of the jets was worked out it was found to be more than 2,800 km/h. Such high speeds implied that the jets are fed by pressurised water vapour that shoots through narrow openings – which act like rocket nozzles – in the moon's icy surface. Researchers identified four distinct jets within the plume where the water vapour appears to be travelling faster at that speed. But reaching that speed "is hard to do without liquids," according to Candice Hansen of NASA's Jet Propulsion Lab in California. The simplest way to generate such pressures would be by evaporating a reservoir of liquid water that lies close to the moon's surface (*Nature*, 27 November 2008).

In this artist's concept, the Cassini *spacecraft makes a close pass over Enceladus, a moon of Saturn, to study plumes from geysers that erupt from giant fissures in the moon's southern polar region. (Karl Kofoed via NASA)*

Earlier studies of Enceladus from *Cassini* had shown that although the surface temperatures were far below freezing, there were relatively warm spots in the south polar region. Scientists traced the internal heating patterns that could create such warm spots, and concluded that temperatures could be above freezing merely a few metres beneath the surface. According to the scientists, it could be warm enough 10 metres or so beneath the surface, and there is enough pressure to keep liquid water stable at that depth. According to the *Cassini* team, water could be heated to the boiling point far beneath the surface, pushing up through the cracks on Enceladus's surface. The source of the heating could be molten rock, perhaps extending nearer to the surface in the south pole region.

During a Cassini flyby in March 2008, NASA scientists had steered the spacecraft through the plume and detected not only water vapour but also methane, carbon dioxide, and other organic molecules – ideal recipe for microbial life to evolve. But it is too early to predict about the existence of life on the Saturnian moon.

Artificial bone marrow developed

Chemical engineers have developed a scaffold that mimics bone marrow allowing researchers to produce blood cells and simplify drug testing. This development could lead to simpler pharmaceutical drug testing, closer study of immune system defects and a continuous supply of blood for transfusions. The substance grows on a 3-D scaffold that mimics the tissues supporting bone marrow in the body. The biomedical scaffold was developed by Nicholas Kotov, professor of chemical, materials, and biomedical engineering in the University of Michigan (*Biomaterials*, 2008; DOI: 10.1016/j.biomaterials.2008.10.041).

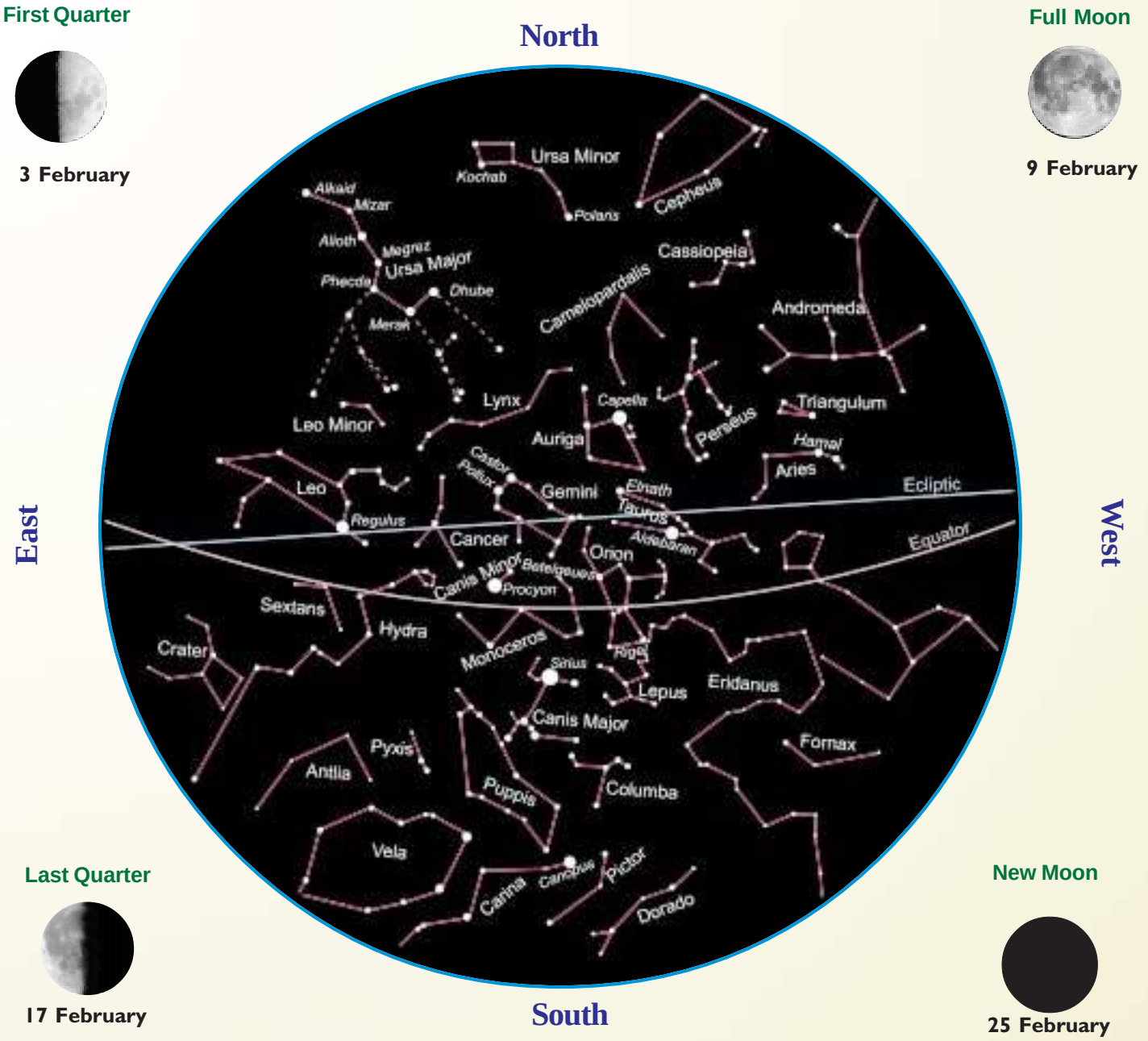
Bone marrow is a complicated material to replicate. According to Kotov, the scaffold for this work had to be designed from scratch closely mimicking real bone marrow because there are no suitable commercially products. To create the scaffolds, he used a polymer that readily allows nutrients to pass through it; this was moulded with tiny spheres ordered like billiard balls. He then dissolved the spheres leaving the required complex porous geometry, which was then seeded with bone marrow cells.

The first successful artificial bone marrow has been shown to possess two of the essential functions of bone marrow: it can replicate blood stem cells and produce B cells. The latter are the key immune cells producing antibodies that are important to fighting many diseases. The researchers later demonstrated that artificial marrow can produce a human-like response to an infectious flu virus. To determine whether the substance behaves like real bone marrow, the scientists implanted it in mice with immune deficiencies, which subsequently grew blood vessels and produced human immune cells.

At present the biochemical scaffold for making artificial bone marrow is not made to be implanted in the body. It is designed to function in a test tube. According to the researchers, scaling up the system could lead to the mass production of blood cells for transfusions. It will also offer simpler drug testing techniques; chemotherapy drugs can suppress bone marrow function by reducing B cell production – by using the artificial marrow, drug developers could highlight such side affects before human drug trials.

Artificial marrow replicates blood stem cells and produces immune cells like natural marrow.

Sky Map for February 2009



The sky map is prepared for viewers in Nagpur (21.09°N, 79.09°E). It includes constellations and the brighter stars. For viewers south of Nagpur, constellations of the southern sky will appear higher up in the sky, and those of the northern sky will appear nearer the northern horizon. Similarly, for viewers north of Nagpur, constellations of northern sky will appear higher up in the sky, and those of the southern sky will appear nearer the southern horizon. The map can be used at 10 PM on 1 February, at 9 PM on 15 February and at 8 PM on 28 February.

Tips for watching the night sky:

1. Choose a place away from city/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.

Visibility of Planets▫

	Rising	Setting	In the Zodiac
Mercury	05:12	16:14	Sagittarius -Capricorns
Venus	06:58	19:41	Pisces
Mars	05:09	16:35	Sagittarius - Capricorns
Jupiter	04:20	15:31	Capricorns
Saturn	17:46	06:15	Leo
Uranus*	06:20	18:12	Aquarius
Neptune*	04:51	16:12	Capricorns

▫ Time shown is subject to vary (± 1 hr) from place to place.
* Not naked eye object

Sky Event

Date	IST	Event
08	01:38	Moon at perigee
09	20:08	Penumbral Lunar Eclipse
14	02:29	Mercury at greatest Elongation (W)
17	23:20	Mars-Jupiter
19	22:30	Moon at Apogee
23	13:19	Moon-Mars
23	06:36	Moon-Jupiter
28	04:30	Moon-Venus

▫ **Arvind C. Ranade**
E-mail : rac@vigyanprasar.gov.in

Astronomy

VP Publications

Vigyan Prasar

New Publications and Activity Kits from Vigyan Prasar

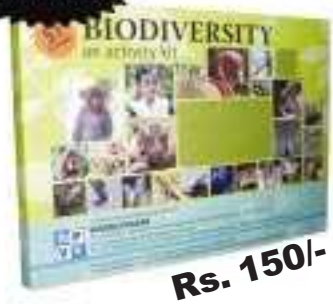
Ideal for Schools

10 titles on different themes of Planet Earth brought out on the occasion of International Year of Planet Earth 2008

1. Deserts	Rs. 85/-
2. Earth's Changing Climate	Rs. 60/-
3. Life on Earth	Rs. 65/-
4. Mangroves	Rs. 60/-
5. Mountains	Rs. 70/-
6. Planet Earth in a Nutshell	Rs. 65/-
7. Snakes	Rs. 65/-
8. The Violent Earth	Rs. 75/-
9. Water	Rs. 75/-
10. The Weather Riddle	Rs. 65/-

ACTIVITY KITS/ MODULES

51 ACITIVITIES



Rs. 150/-

Vigyan Prasar has brought out two activity kits on "Biodiversity" and "Weather". Each kit comprises of hands-on activities illustrating scientific principles and the natural phenomena and processes, which are self explanatory.

The scientific concepts, information and principles, phenomena and dynamics of natural processes relating to Weather and Biodiversity can be studied/learnt through the hands-on activities given in the kits.

36 ACITIVITIES

Rs. 150/-

For more details please write to :-

Director
VIGYAN PRASAR
A-50, Institutional Area, Sector-62, NOIDA- 201307, U.P. , INDIA.
Phone : 0120-2404430,31,35,36 Fax : +91-120-2404437
email : info@vigyanprasar.gov.in, website : http://www.vigyanprasar.gov.in/

Available in Hindi & English

Release of Vigyan Prasar Publication

Vigyan Prasar's publication "To Reach the Stars or Dig the Earth – My Journey Through Doing Science in India" by Prof. G. Padmanaban, Director of The Indian Institute of Science (IISC), Banglore on the occasion of the Centenary Celebrations of IISC. (Second from L to R)

YOUR OPINION

Dream 2047 will invite your opinion on a specific topic every month. The reader sending the best comments will receive a popular science book published by VP. Selected comments received will also be published in *Dream 2047*. The comments should be limited to 400 words.

This month's topic:

"As individuals, are we doing enough to lessen the effects of Global Warming?"

Response should contain full name; postal address with pincode and email ID, if any; and should be accompanied by a recent passport size photograph. Response may be sent by email (**opinion@vigyanprasar.gov.in**) or by post to the address given below. If sent by post, "**Response: *Dream 2047* February 2009**" should be clearly written on the envolope.

Vigyan Prasar
A-50, Institutional Area, Sector-62, NOIDA 201 307
Phone: 91-120-240 4430/35 Fax: 91-120-240 4437
Email: info@vigyanprasar.gov.in Website: www.vigyanprasar.gov.in

Letters to the Editor

A Great Job

You and the Vigyan Prasar team are doing a great job in bringing out the English/Hindi edition of *DREAM 2047*. You are presenting concrete scientific information in simple terms to reach people. I am aware that many scientists who frequent DST, etc., and many other "successful" persons won't bother about it, as mostly they are engrossed in themselves and don't worry about the other 90% of India. But your work will help at least some of the 90%.

I suggest you look at Shiksha India website & portal. I am associated with it. Shiksha content is available in English, Hindi and part Tamil. It is totally free for download from the Shiksha Portal. I wonder whether we can put articles from *DREAM 2047* (past and present), in English and Hindi on Shiksha India portal, as then it will reach many teachers and students.

Dr Y.S.Rajan
Principal Adviser
Confederation of Indian Industry (CII)
Plot No-249F, Sector-18, Phase-IV,
Udyog Vihar, Gurgaon-122 015

An informative magazine

Your magazine has given me lot of information and it helps me to expand my knowledge. We are running a registered NGO named PRASTUTI; working with marginalised and less-privileged children for the last ten years in the capital through the medium of theater, which has been recognised as an effective medium for creating mass-awareness on various socio-cultural aspects among the culturally deprived. I feel, we can share contents of *DREAM 2047* with our children and I would like to receive your magazine every month at the address given below.

Barin Chakraborty
PRASTUTI
RZ /J/14/231, West Sagarpur,
New Delhi – 110046.